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TM 11-444

WAR DEPARTMENT

TECHNICAL MANUAL

SOUND RANGING SET GR-3-C

12 June, 1943

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WAR DEPARTMENT

Washington, 12 June, 1943

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CONTENTS

SECTION — Paragraph

I. DESCRIPTION
- Use and characteristics — 1
- Major components — 2
- Packing of major components — 3
- Description of central station equipment — 4
- Description of microphone equipment — 5
- Description of outpost equipment — 6

II. INSTALLATION AND OPERATION
- Initial procedure — 7
- Installation — 8
- Cords — 9
- Batteries — 10
- Fuses, vacuum tubes, and lamps — 11
- Switchboard BD-62-(*) — 12
- Control Board BD-85-(*) — 13
- Oscillograph Equipment IE-14-(*) — 14
- Relay Unit BK-9-(*) — 15
- Protector AR-8 — 16
- Microphone equipment — 17
- Outpost equipment — 18
- Preliminary over-all tests — 19
- Operation — 20

III. FUNCTIONING OF PARTS
- Switchboard BD-62-(*) — 21
- Control Board BD-85-(*) — 22
- Relay Unit BK-9-(*) — 23
- Oscillograph Equipment IE-14-(*) — 24
- Oscillograph Unit M-166-A — 25
- Microphone T-21-(*) — 26
- Protector AR-8 — 27
- Cord CD-250-A — 28
- Outpost equipment — 29

IV. MAINTENANCE
- General — 30
- Care and cleaning — 31
- Circuits — 32
- Relays — 33
- Microphone T-21-(*) — 34
- Control Board BD-85-(*) — 35
- Relay Unit BK-9-(*) — 36
- Switchboard BD-62-(*) — 37

V. SUPPLEMENTARY DATA
- List of replaceable parts — 38
- Parts list — 39
- Index of manufacturers — 40

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This technical manual supersedes TM 11-444 dated 25 January, 1943.

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ILLUSTRATIONS

Figure		Page
1	Sound Ranging Set GR-3-C, recording equipment assembly	4
2	Oscillograph Equipment IE-14-(*), top view with covers removed	6
3	Oscillograph Equipment IE-14-(*), side view with covers removed	8
4	Galvanometer magnet assembly, Cord CD-475, and Oscillograph Unit M-166-A	10
5	Chest CH-40-(*), showing pistonphone and 5 Microphones T-21-(*)	12
6	Chests CH-44-(*), CH-45-(*), CH-46-(*), CH-47-(*), CH-48-(*), and Cover BG-74	14
7	Protector AR-8 (disassembled) and Cord CD-250-A	16
8	Microphone T-21-(*) and Insulating Bag BG-97	18
9	Microphone Shelter BE-66-A	18
10	Outpost equipment — Outpost Unit BE-51, Outpost Connecting Box BE-71, and Telephone EE-8-(*)	20
11	Outpost wiring diagram	32
12	Switchoard BD-62-(*), rear view	36
13	Switchboard BD-62-(*), circuit diagram	38
14	Control Board BD-85-(*) (rear view) and Relay Unit BK-9-(*)	40
15	Control Board BD-85-(*), circuit diagram	42
16	Relay Unit BK-9-(*), circuit diagram	43
17	Oscillograph Equipment IE-14-(*), circuit diagram	44
18	Microphone T-21-(*), disassembled	46
19	Microphone T-21-(*), circuit diagram	48

SAFETY NOTICE

THIS EQUIPMENT USES VOLTAGES HIGH ENOUGH TO BE DANGEROUS TO HUMAN LIFE. DON'T ATTEMPT ANY REPAIR OR ADJUSTMENT WITHIN THE EQUIPMENT WHILE THE CURRENT IS ON. DON'T UNDERTAKE THE REPAIR OF THIS EQUIPMENT OR ITS ASSOCIATED COMPONENTS UNLESS YOU ARE AUTHORIZED TO DO SO.

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DESTRUCTION NOTICE

WHY—To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN—Ordered by your commander, or when you are in immediate danger of capture.

HOW—1. Smash.—Use sledges, axes, hand-axes, pick-axes, hammers, crowbars, heavy tools, trucks, tanks, etc.

2. Cut.—Use axes, hand-axes, machete etc.

3. Burn.—Use gasoline, kerosene, alcohol, oil, flame-throwers, incendiary grenades, etc.

4. Explosives.—Use firearms, grenades, TNT, etc.

5. Disposal.—Bury broken pieces in slit trenches, fox-holes, other holes. Throw in streams, scatter.

6. USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT.

WHAT.—1. Smash.—Oscillograph equipment IE-14-(*): galvanometer magnet with oscillograph units, spare oscillograph units, lamps, automatic camera, magazine, motor, lenses, mirrors, tuning fork, timing motor, counter, clock, sockets, terminals, top, sides, ends, bottom.

Control Board BD-85-(*): all meters, knobs, terminals, keys, attenuators, transformers, fuses, sockets, resistor, jack strip, panel, top, side, ends, bottom.

Relay unit BK-9-(*): relays, rheostat, resistors, capacitor, chassis, housing.

Switchboard BD-62-(*): panel, sockets, drops, keys, capacitors, resistors, jacks, fuses, relays, transformer, coils, top, back, ends, bottom.

Other central station equipment: batteries, telephones, headsets, chest sets, supporting frame, protector housing and internal assembly, all test sets, all tool sets, spare parts, photographic supplies, chest.

Microphone T-21-(*): microphone unit including condenser head and plugs, tubes, relay, batteries, capacitors, resistors, sockets, chassis, housing, shelter, Protector AR-4.

Output Unit BE-51: meter, resistor, switch, case.

Outpost Connecting Box BE-71: terminals, capacitor, choke-coil, box.

2. Cut.—All cords, wires, tubing, bags, covers.

3. Burn.—Pile up and burn all broken pieces, chests, bags, covers, wires, cords, circuit diagrams, instruction books, recording paper, photographic materials.

4. Explosives.—Use any explosives on parts not smashed.

5. Disposal.—Bury all broken pieces. Microphone stations can be buried in microphone holes.

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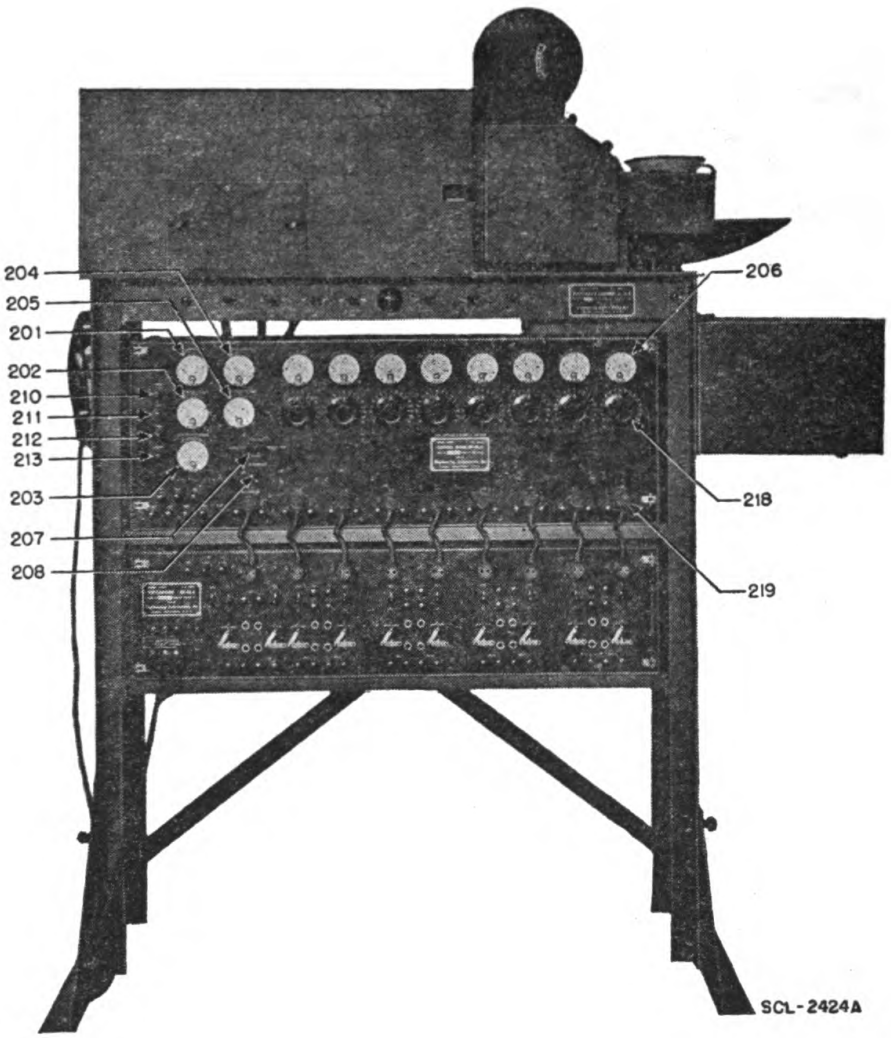

Figure 1.—Sound Ranging Set GR-3-C—recording equipment assembly.

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SOUND RANGING SET GR-3-C

Section I

DESCRIPTION

	Paragraph
Use and characteristics	1
Major components	2
Packing of major components	3
Description of central station equipment	4
Description of microphone equipment	5
Description of outpost equipment	6

1. USE AND CHARACTERISTICS.

a. Sound Ranging Set GR-3-C is designed to detect the sound of artillery fire or shell detonation and record the difference in arrival time of the sound wave at a maximum of eight microphone locations. The microphones may be placed in various geometrical configurations (line, arc, triangle, space array) at intervals up to a maximum of 2,000 yards. Either one of two outposts are located forward of the array of microphones at a distance sufficient to intercept the sound wave and start operations of the recording equipment before the sound reaches the microphones.

b. The signal detected by each microphone is locally amplified and transmitted over wire lines to a central station where it is recorded photoghaphically by an oscillograph. The record exhibits identifying characteristics of the sound waves and is used for reading the differences in times of arrival of the same sound at the different microphones. This is explained in detail in FM 6-120, Field Artillery Field Manual, The Observation Battalion.

c. The weights of the individual chests when packed for transportation are as follows:

Chest	*Weight, packed*
CH-40-(*)	205 lbs.
CH-44-(*)	70 lbs.
CH-45-(*)	116 lbs.
CH-46-(*)	75 lbs.
CH-47-(*)	95 lbs.
CH-48-(*)	160 lbs.

(*) The asterisk within parenthesis denotes the applicable suffix letter.

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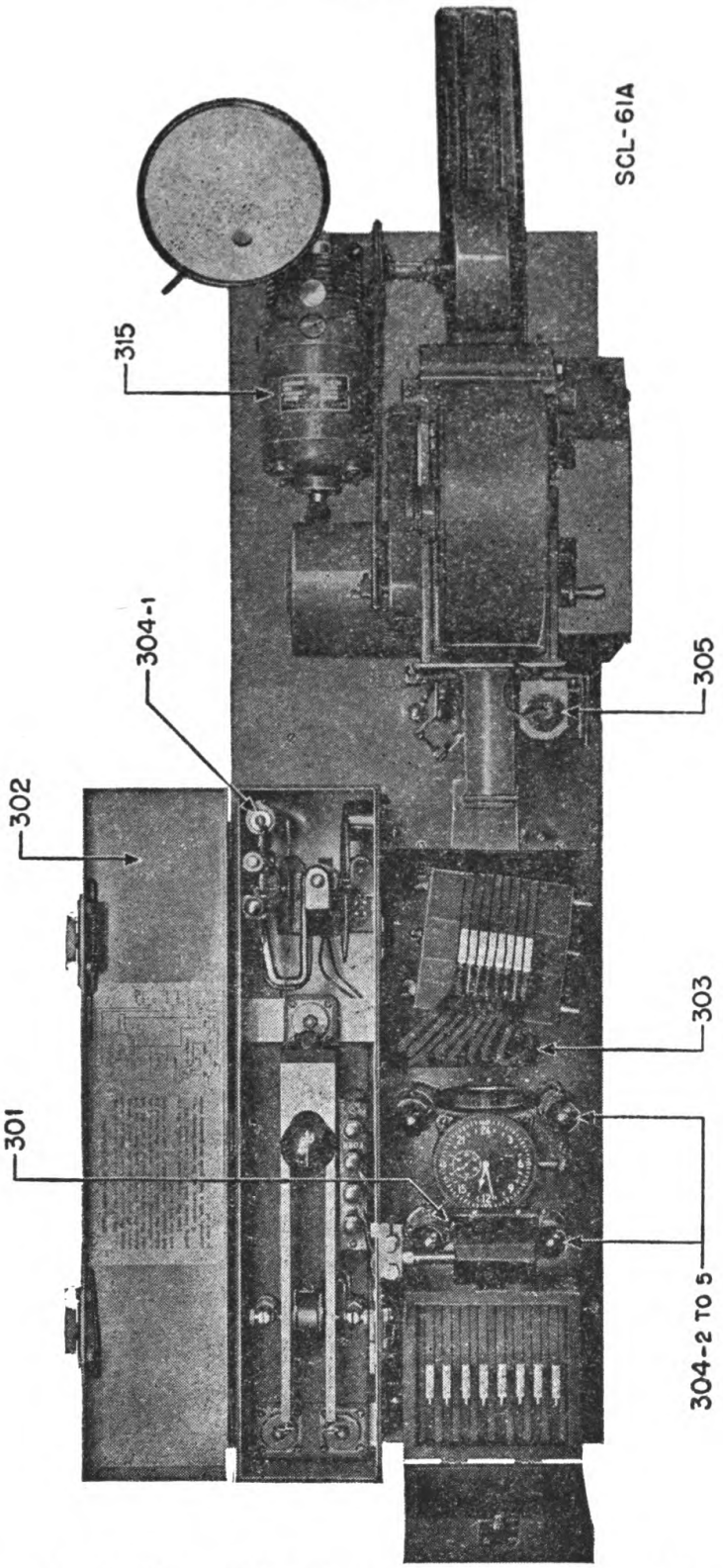

Figure 2.—Oscillograph Equipment IE-14-(*)—top view with covers removed.

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d. The set, as issued, does not include necessary field wire, battery charger, or transportation equipment. Spare parts, accessories, and supplies sufficient for operation during normal supply intervals are included. The complete equipment, including packed chests ready for transport, and all auxiliary equipment, weighs approximately 2,600 pounds and displaces approximately 60 cubic feet.

e. References made to type numbers, followed by parentheses (*), will be understood to cover interchangeable components as follows:

Reference	*Includes*
Chest CH-40-(*)	Chests CH-40-B and CH-40-C
Chest CH-44-(*)	Chests CH-44-A and CH-44-C
Chest CH-45-(*)	Chests CH-45-A and CH-45-C
Chest CH-46-(*)	Chests CH-46-A and CH-46-C
Chest CH-47-(*)	Chests CH-47-A and CH-47-C
Chest CH-48-(*)	Chests CH-48-A and CH-48-C
Control Board BD-85-(*)	Control Boards BD-85-A and BD-85-C
Handset TS-9-(*)	Handsets TS-9-A through TS-9-Q
Microphone T-21-(*)	Microphones T-21-B and T-21-C
Oscillograph Equipment IE-14-(*)	Oscillograph Equipments IE-14 and IE-14-C.
Relay Unit BK-9-(*)	Relay Units BK-9 and BK-9-C
Switchboard BD-62-(*)	Switchboards BD-62-B and BD-62-C
Telephone EE-8-(*)	Telephones EE-8-A and EE-8-B
Test Set EE-65-(*)	Test Sets EE-65-A through EE-65-D

2. MAJOR COMPONENTS.

The major components of Sound Ranging Set GR-3-C are as follows:

	Dimensions (in inches)	*Unit Weight (pounds)*
Oscillograph Equipment IE-14-(*)	19 x 11 x 36½	90
Control Board BD-85-(*)	12½ x 8¾ x 32⅜	36

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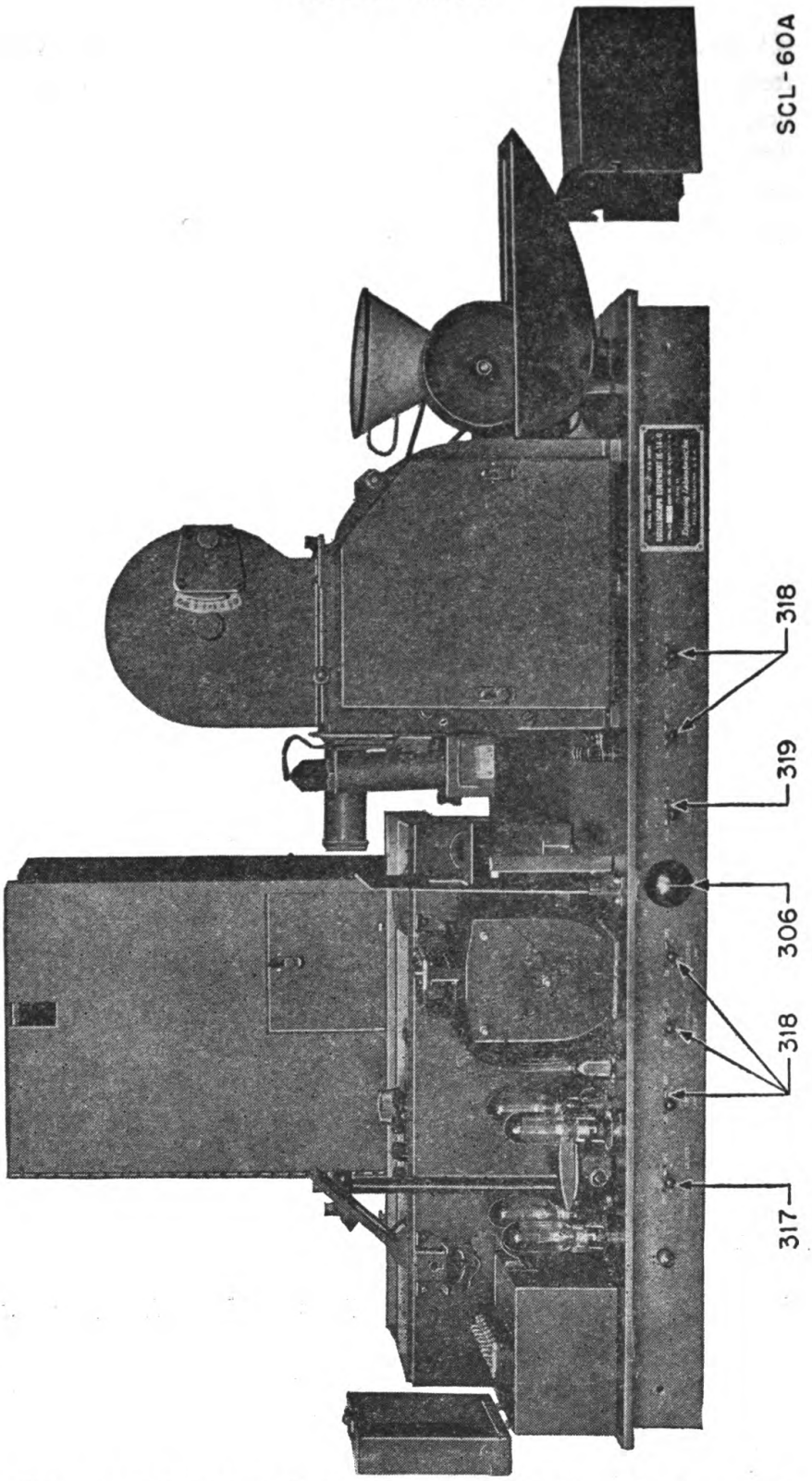

Figure 3.—Oscillograph Equipment IE-14-(*)—side view with covers removed

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	Dimensions (in inches)	*Unit Weight (pounds)*
Switchboard BD-62-(*)	8½ x 8 ¾ x 32⅜	27.4
Relay Unit BK-9-(*) (includes one spare)	4½ x 8 x 4½	6
Protector AR-8	16 x 12 diam.	13
Microphone T-21-(*)	16 x 6 diam.	24
Microphone Shelters BE-66-A	21 diam.	4
Protector AR-4	7⅝ x 3½ x 3	1
Bag (for microphone) BG-97	18 x 5 x 2	1
Outpost Unit BE-51	2½ x 3¼ x 7	6
Outpost Connecting Box BE-71	4½ x 2 x 1½	1
Telephones EE-8-(*)	3½ x 7 7/16 x 9½	4
Tool Set TE-6	6 cu. ft.	108
Tool Equipment TE-37	4 x 2 diam.	.75
Test Set EE-65-(*). (See note)	8 x 10 x 6	14
Test Set I-56-C	11 x 13½ x 9½	26
Chest CH-40-(*)	11 x 25¼ x 47½	35
Chest CH-44-(*)	15¾ x 14½ x 25½	46
Chest CH-45-(*)	13¼ x 15½ x 48½	57
Chest CH-46-(*)	13⅛ x 12½ x 36½	34
Chest CH-47-(*)	16⅝ x 12¼ x 38¼	37
Chest CH-48-(*)	17⅜ x 14¾ x 43¼	53
Chest BC-5	28⅞ x 18⅛ x 12	35
Cover (for oscillograph assembly) BG-74	18 x 18 x 4	8.5

Note: Test Sets EE-65-A (3F4065A) through EE-65-D (3F-4065D) may be issued.

3. PACKING OF MAJOR COMPONENTS.

All units of the equipment can be packed in chests for convenient transportation so that ordinary handling will not affect per-

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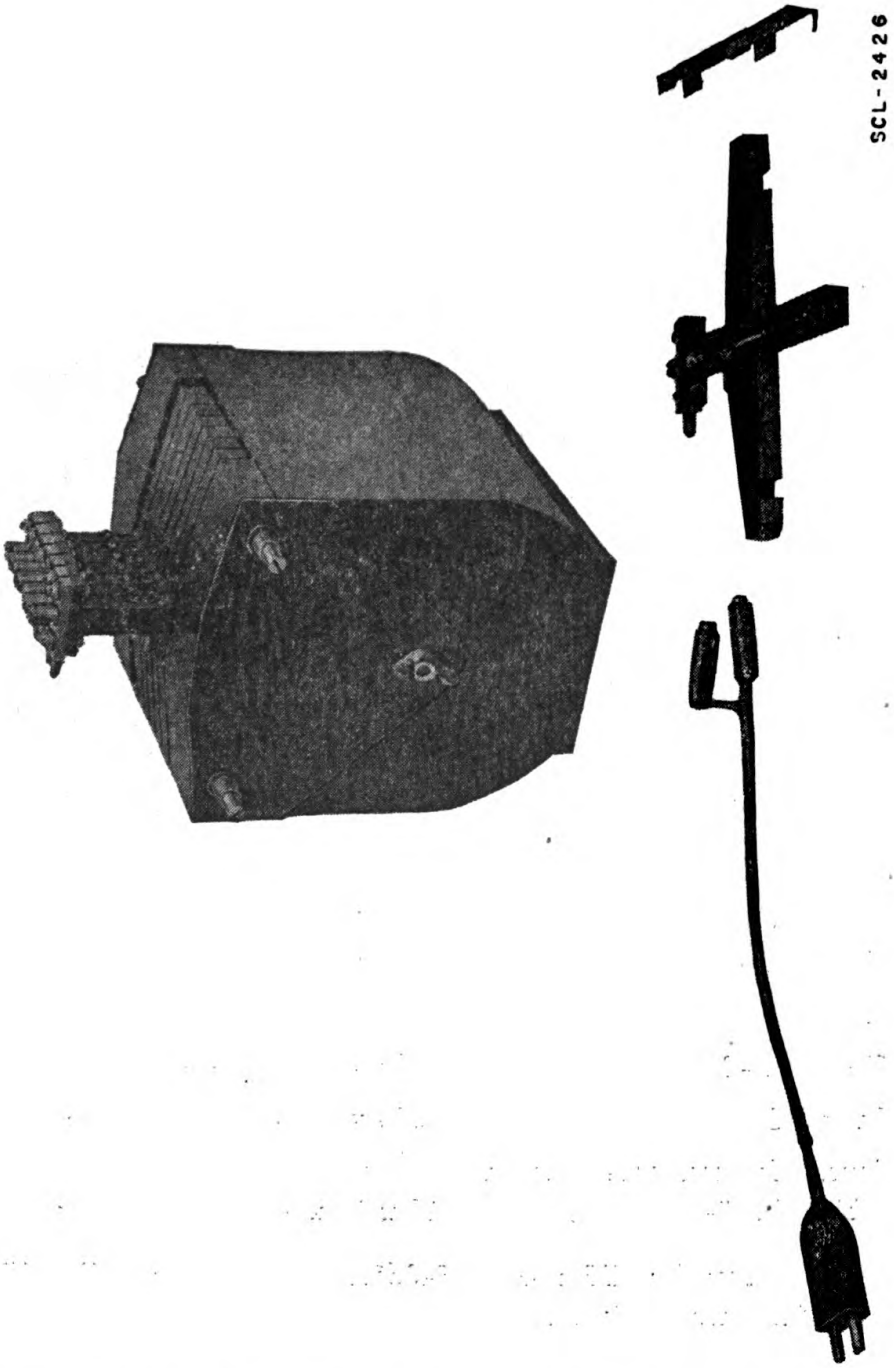

Figure 4.—Galvanometer magnet assembly, Cord CD-475, and Oscillograph Unit M-166-A.

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formance. Chest BC-5 is used for general purposes. The other chests (figs. 5 and 6) are used specifically as follows:

a. **Chest CH-40-(*)**

Microphones T-21-(*)

b. **Chest CH-44-(*)**

Lamps

Tubes

Miscellaneous small items

c. **Chest CH-45-(*)**

Relay Unit BK-9-(*) (spare)

Framework of Oscillograph Equipment IE-14-(*)

Magazines, fixing tray, and roller

d. **Chest CH-46-(*)**

Switchboard BD-62-(*)

e. **Chest CH-47-(*)**

Control Board BD-85-(*)

Relay BK-9-(*)

f. **Chest CH-48-(*)**

Oscillograph Equipment IE-14-(*), less framework

4. DESCRIPTION OF CENTRAL STATION EQUIPMENT.

a. **General.**

The central station equipment includes the following:

(1) Recording equipment assembly

(2) Testing equipment

(3) Tools

(4) Photographic supplies

(5) Batteries and spare parts

(6) Packing equipment

(7) Protector AR-8

(8) Cord CD-250-A

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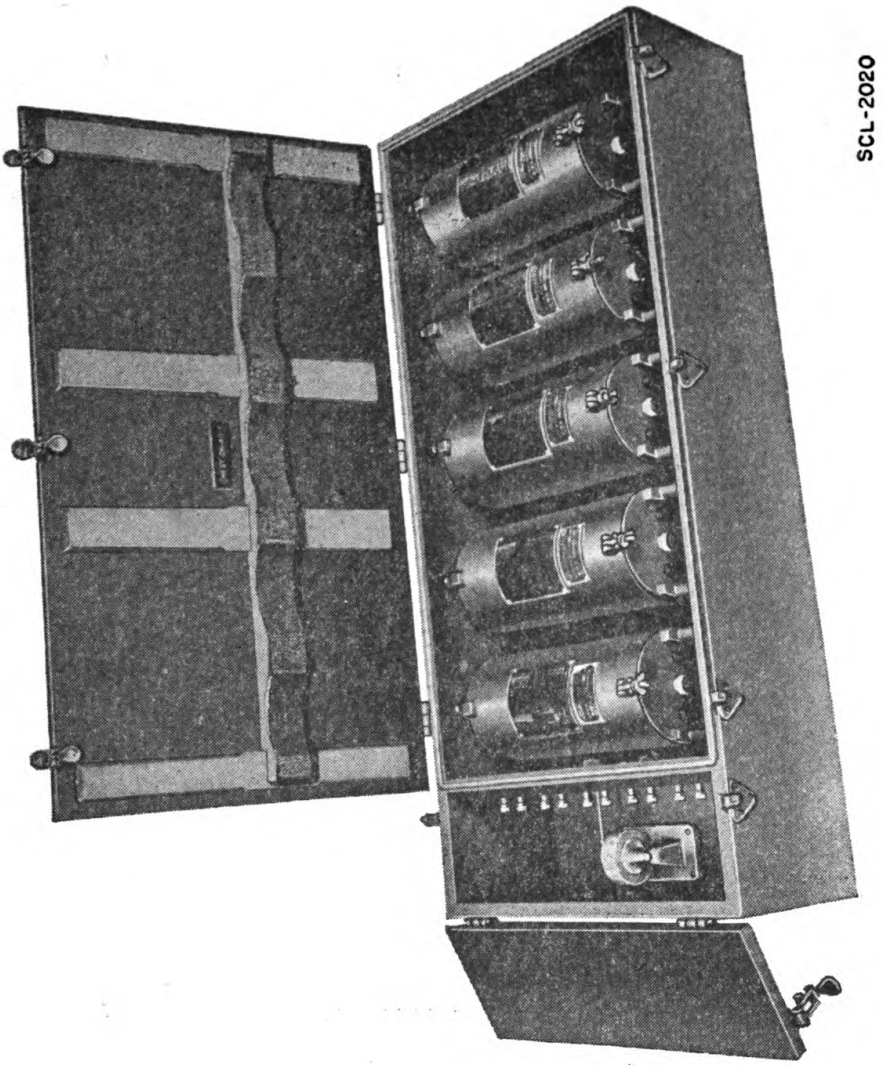

Figure 5.—Chest CH-40-(*), showing pistonphone and five Microphones T-21-(*).

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b. Recording Equipment Assembly.

The recording equipment (fig. 1) consists of the following major components:

Oscillograph Equipment IE-14-(*), with Oscillograph Units M-166-A

Control Board BD-85-(*)

Switchboard BD-62-(*)

Relay Unit BK-9-(*)

(1) Osillograph Equipment IE-14-(*) includes the framework and equipment mounted on its upper portion (figs. 2 and 3). This equipment consists of the timing unit, the galvanometer magnet, the identification panel, suitable lamps and optical system, the automatic camera with magazine, the fixing tray, and covers to prevent entrance of stray light. An operating panel is located on the lower front part of the equipment.

(2) Oscillograph Units M-166-A (fig. 4) are designed to fit into the galvanometer magnet of Oscillograph Equipment IE-14-(*). Eight are in use and eight are stored in a box mounted on the left end of the table top. Electrical connection to Oscillograph Equipment IE-14-(*) is made with Cords CD-475.

(3) Control Board BD-85-(*) (figs. 1 and 14) is housed in a metal case with the control panel forming the front. This unit is mounted in the middle part of the oscillograph assembly.

(4) Switchboard BD-62-(*) (figs. 1 and 12) is housed in a metal case with the operating panel forming the front. This unit is mounted below Control Board BD-85-(*) in the assembly.

(5) Connection is made between Control Board BD-85-(*) and Oscillograph Equipment IE-4-(*) with one Cord CD-443 and two Cords CD-444. These consist of multiple conductor cordage terminated with suitable plugs. Connection is made between Control Board BD-85-(*) and Switchboard BD-62-(*) with jumper wires connecting corresponding binding post terminals for the power circuits, and with Cords CD-428 for the microphone and outpost lines. These cords consist of two-conductor cordage terminated with suitable plugs to permit an easy reversal of polarity. Binding posts paralleling the plug sockets in Control Board BD-85-(*) and Switchboard BD-62-(*) are for emergency use.

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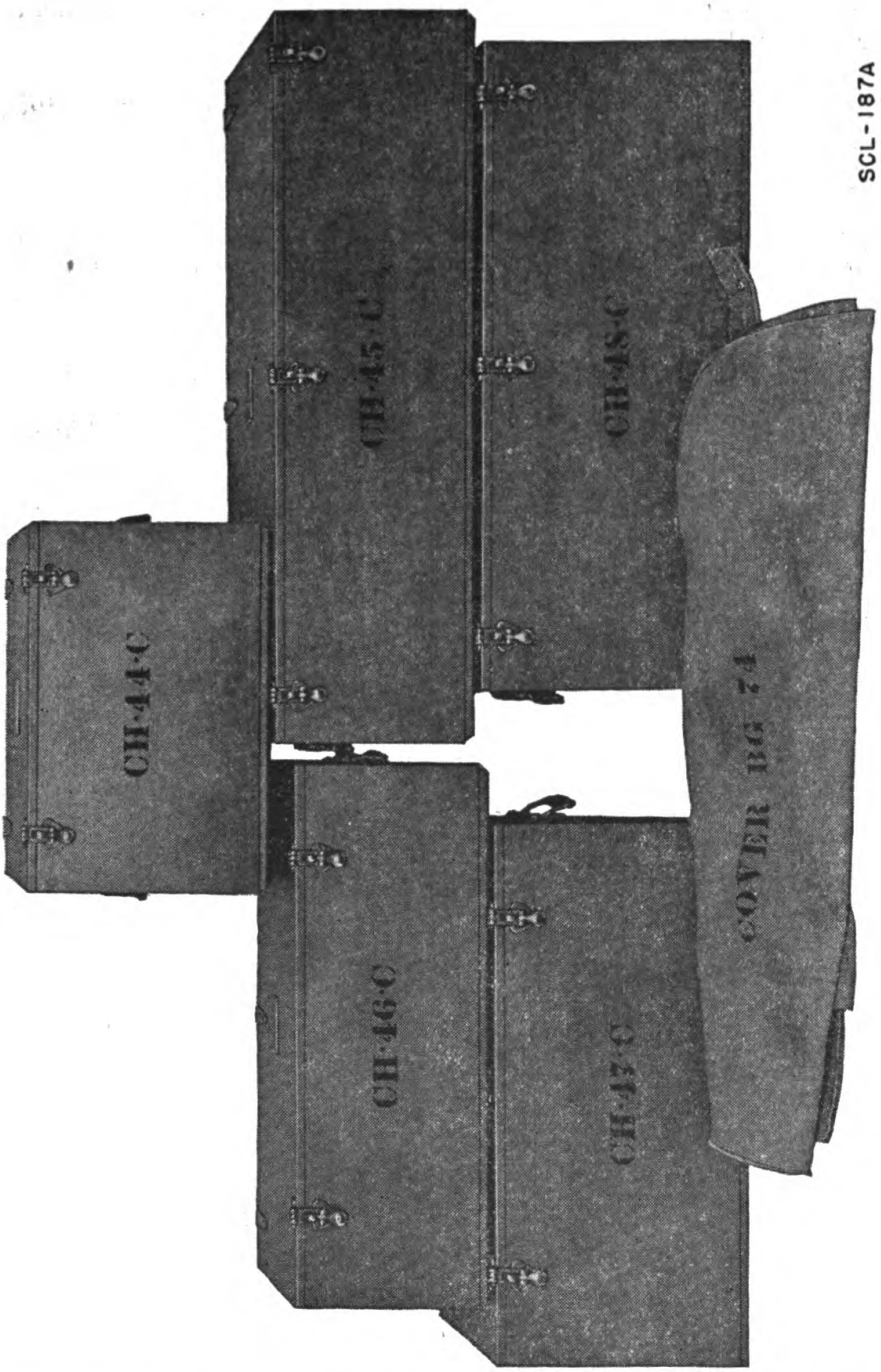

Figure 6.—Chests CH-44-(*), CH-45-(*), CH-46-(*), CH-47(*), CH-48-(*), and Cover BG-74

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(6) Relay Unit BK-9-(*) (fig. 14) fits into the left end of Control Board BD-85-(*), and is accessible through an opening in the control-box housing.

c. Testing Equipment.

The testing equipment consists of the following:

(1) Test Set EE-65-(*) is designed for testing and locating trouble on magneto telephone lines and equipment. (This test set is covered in TM11-361.)

(2) Test Set 1-56-C is a universal radio servicing set consisting of a radio set analyzer, output meter, voltohmmeter, and tube checker. Power supply for the tube checker is obtained from a 110-120-volt, 60-cycle, a-c line. A pamphlet of instructions is supplied with this test set.

(3) Photographer's Thermometer PH-28 is used to check the temperature of photographic chemical solutions.

(4) Chest CH-40-(*) (fig. 5) is a combined carrying chest for Microphones T-21-(*) and a testing chamber to check the operation of the complete sound recording channels. The microphone compartment is air-tight. At one end of the chest and connected to the microphone compartment is a pistonphone which provides a uniform sinusoidal variation in pressure over the frequency range necessary to determine the over-all response characteristic of each channel.

(5) The battery tester permits the reading of the voltage of each storage battery cell under load, and gives an indication of the internal condition of the battery.

d. Tools.

The tools consist of Clamp MM-7 (for use in replacing microphone diaphragms), a Soldering Iron TL-139, Tool Set TE-6, and Tool Equipment TE-37. See list of Replaceable Parts (par. 38).

e. Photographic Supplies.

The photographic supplies are given in the parts list, paragraph 39.

f. Batteries.

The batteries in use, the spare batteries, and spare parts are given in the list of components (par. 39).

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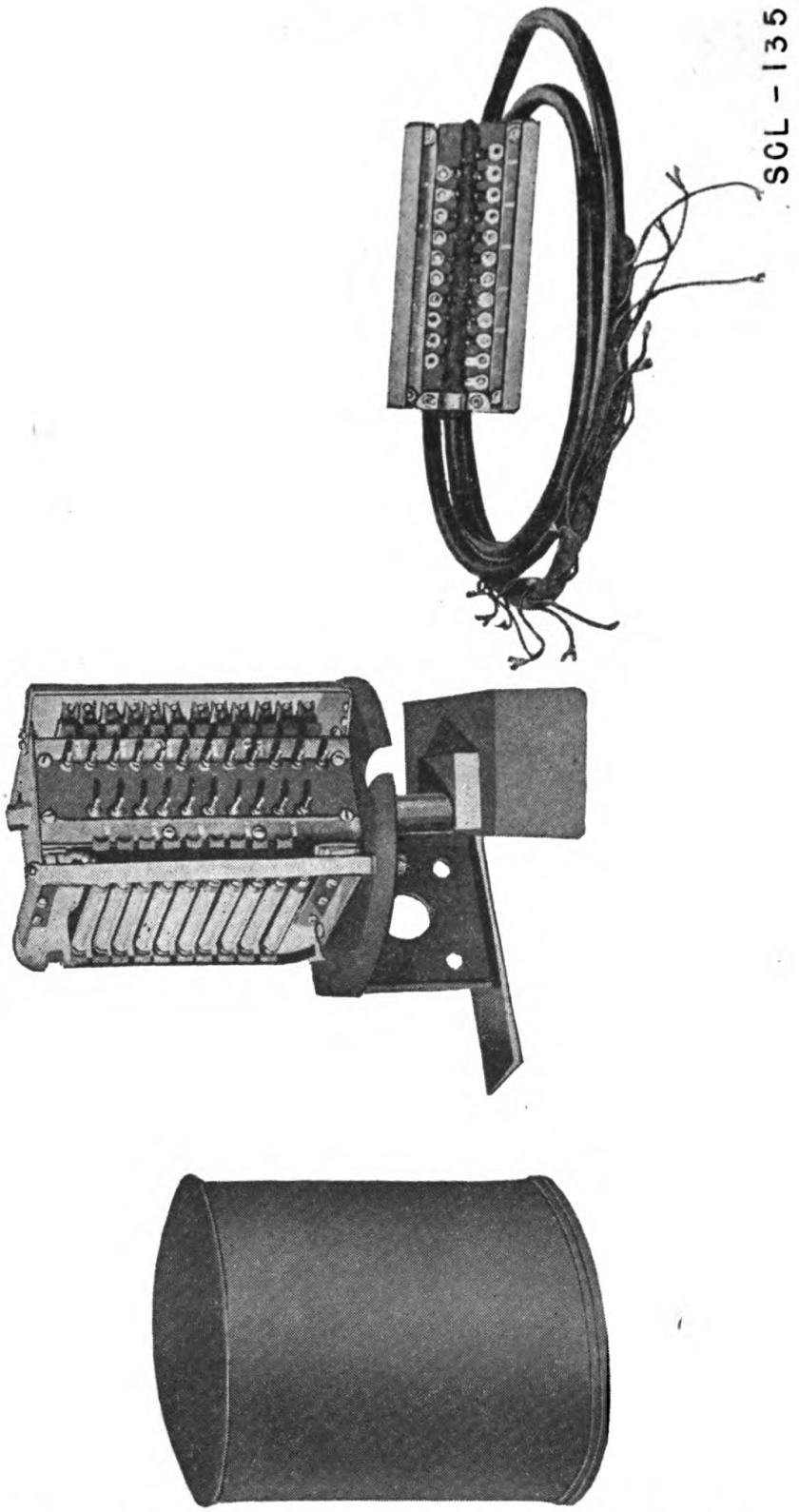

Figure 7.—Protector AR-8 (disassembled) and Cord CD-250-A.

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g. Packing Equipment.

The packing equipment consists of the chests given in the list of components and shown in figures 5 and 6. They are made of wood and have hinged covers secured by rugged clamps. Each chest is provided with carrying handles.

h. Protector.

Protector AR-8 (fig. 7), normally installed at the line terminal, is an assembly of fuses and spark-gap blocks mounted in a round galvanized iron case.

i. Cord CD-250-A.

Cord CD-250-A (fig. 7 is used to connect the incoming terminals of Switchboard BD-62-(*) to Protector AR-8. The bakelite plug at one end of Cord CD-250-A fits into Protector AR-8. This permits quick connection of the incoming lines to the recording equipment assembly (fig. 1).

5. DESCRIPTION OF MICROPHONE EQUIPMENT.

Each microphone equipment consists of one Microphone T-21-(*), one Insulating Bag BG-97 (fig. 8), one Microphone Shelter BE-66-A (fig. 9), and one Protector AR-4. The microphone is of the condenser type. A cylindrical metal case about 14 inches long and 6 inches in diameter, with a carrying handle, is part of this microphone. The microphone is inclosed in Bag BG-97 to prevent earth grounding of the microphone case. The microphone shelter is made of metal and canvas, and is about 20 inches in diameter. It has two insulating spring hooks on which to hang the microphone. Protector AR-4 has two fuses mounted in a small metal container.

6. DESCRIPTION OF OUTPOST EQUIPMENT.

Each outpost equipment consits of one Outpost Unit BE-51, one Outpost Connecting Box BE-71, and normally, one Telephone EE-8-(*). These items are shown in figure 10. The outpost unit consists of a milliammeter and push switch mounted in a leather case with a carrying strap. The outpost connecting box is a small unit that can be snapped on the telephone carrying strap. It connects the outpost unit and telephone to the line.

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Figure 8.—Microphone T-21-(*) and Insulating Bag BG-97

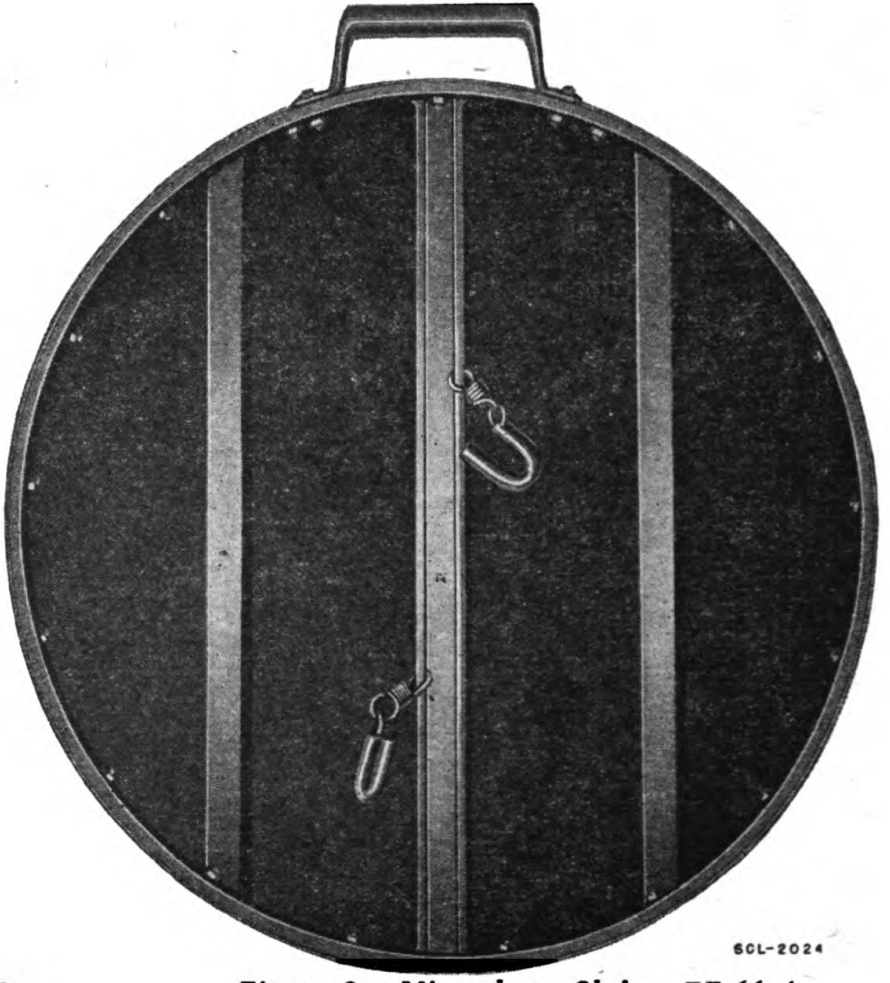

Figure 9.—Microphone Shelter BE-66-A.

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Section II

INSTALLATION AND OPERATION

	Paragraph
Initial procedure	7
Installation	8
Cords	9
Batteries	10
Fuses, vacuum tubes, and lamps	11
Switchboard BD-62-(*)	12
Control Board BD-85-(*)	13
Oscillograph Equipment IE-14-(*)	14
Relay Unit BK-9-(*)	15
Protector AR-8	16
Microphone equipment	17
Outpost equipment	18
Preliminary over-all tests	19
Operation	20

7. INITIAL PROCEDURE.

Take care in unpacking and handling this equipment. Check the items given in the parts list, (paragraph 39).

8. INSTALLATION.

Assemble the recording equipment as illustrated in figure 1, using the wing nuts provided for the purpose. If the central station is a truck or a trailer, bolt the oscillograph assembly to the floor of the vehicle. If the central station is to be a casemate, a dugout, or a laboratory, bolt the recording equipment assembly to a planking. This planking either should be sufficiently wide, or should be secured to the flooring, to prevent the assembly from tipping over. Protect the recording equipment assembly from dust by Cover BG-74 (fig. 6), when not in use.

9. CORDS.

Test all cords for shorts or breaks before installation. Cords CC-66 and CC-67 are used to switch or patch connections on Switch-

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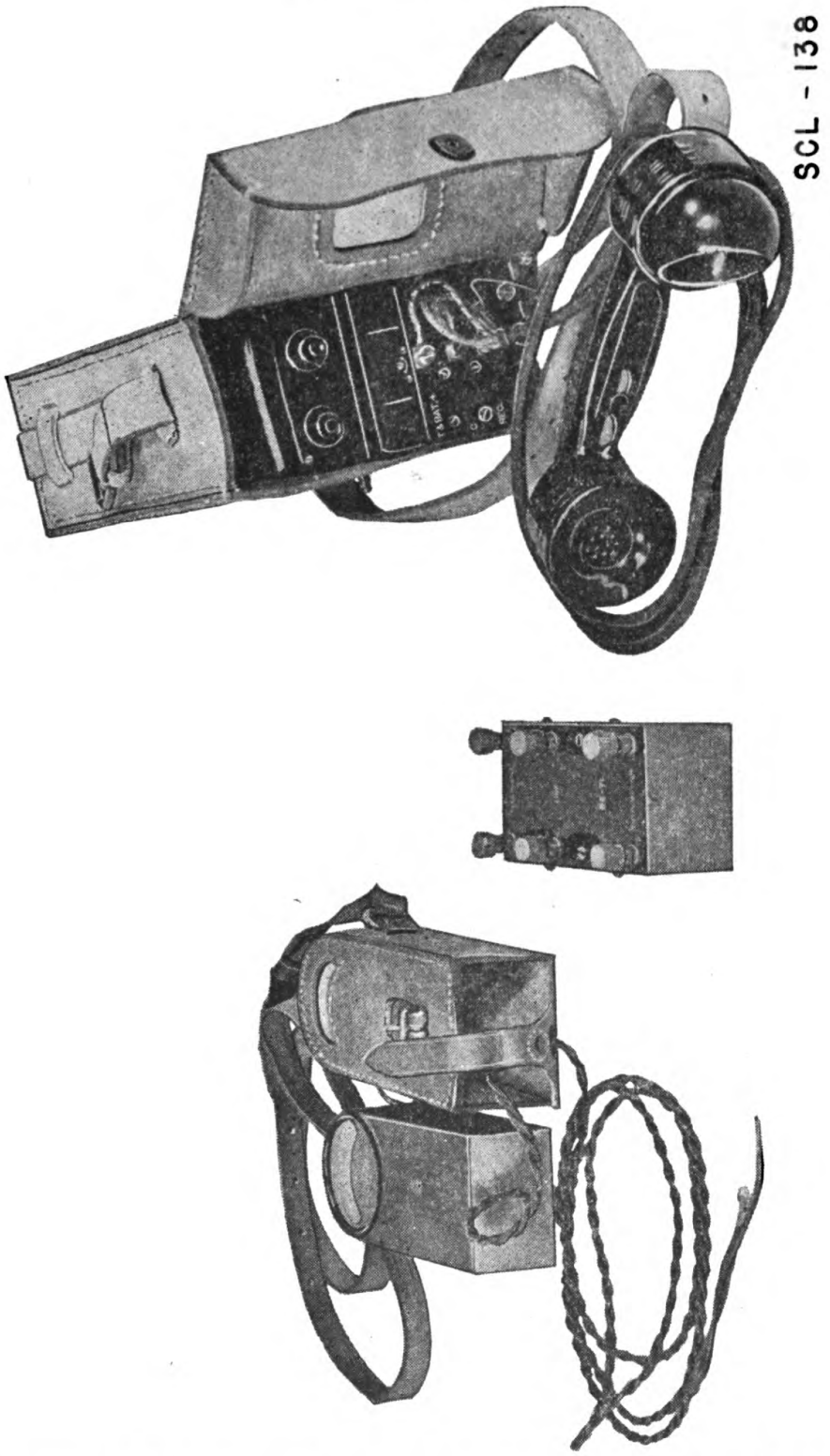

Figure 10.—Outpost equipment—Outpost Unit BE-51, Outpost Connecting Box BE-71, and Telephone EE-8-(*)

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board BD-62-(*). Cords CO-38 are storage battery connectors. Cords CO-50-A connect the required storage battery taps to Control Board BD-85-(*). One Cord CD-433 and two Cords CD-444 connect Control Board BD-85-(*) to Oscillograph Equipment IE-14-(*). Cords CD-428 connect the microphone and outpost circuits of Switchboard BD-62-(*) to Control Board BD-85-(*). Power connections between these two units are made with hook-up wire. Cord CD-250-A connects Switchboard BD-62-(*) to Protector AR-8. One length of two-conductor cordage connects the 90-volt dry cell battery to Control Board BD-85-(*). Cords CD-439 and Cords CD-438 are 20 feet in length. They are similar to Cords CD-443 and Cords CD-444, respectively, and are used when the sound ranging equipment is set up with the major components disposed at a distance from each other, or in emergencies, as replacements for Cords CD-443 and CD-444.

10. BATTERIES.

a. Storage Batteries.

Connect six Batteries BB-29 in series, by means of Cords CO-38, to form a 24-volt station battery. Connect one Battery BB-29 and a single cell of another Battery BB-29 in series by means of a Cord CO-38 to give 6 volts for the recording lamp. Rotate all batteries, including spares, periodically, to maintain the same state of charge. For charging, connect batteries in 32-volt banks. Ascertain the state of charge of each cell by means of a specific gravity test, using a hydrometer. Determine the internal condition of each cell of each battery by means of a load test with the cell tester.

CAUTION.—DON'T USE THE CELL TESTER DURING AND IMMEDIATELY AFTER CHARGING WHEN THE BATTERY IS GASSING. A SPARK MAY IGNITE THE HYDROGEN GAS. BE SURE TO CHARGE BATTERIES IN A WELL VENTILATED PLACE AND BE SURE TO REMOVE VENT CAPS.

b. Dry Cell Batteries.

Two Batteries BA-26, connected in series, form the 90-volt supply of Control Board BD-85-(*). One Battery BA-28 and four Batteries BA-30 are used in each Microphone T-21-(*) to supply the output-tube "C" voltage and the filament current, respectively.

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Batteries BA-30 must be installed upside down in the cylindrical holders of Microphone T-21-(*).

11. FUSES, VACUUM TUBES, AND LAMPS

a. Fuses.

Insert the fuses in Control Board BD-85-(*) and in Switchboard BD-62-(*) as indicated in the circuit diagrams, figures 13 and 15.

b. Vacuum Tubes.

Check the vacuum tubes for filament *open* and for plate or grid short circuits, before inserting them in Microphones T-21-(*).

c. Lamps.

(1) Inspect the lamps before insertion in Oscillograph Equipment IE-14-(*). The recording lamp, Lamp LM-40, is a straight-filament, 4.2-volt lamp. The identification lamps and the time lamp are Lamps LM-30.

(2) Make connection to the stud of the time lamp by means of a short jumper wire, soldered in place.

12. SWITCHBOARD BD-62-(*).

a. Drops.

Adjust the tension of the drop-retaining springs so that the drops are easily operated by the ringing of Telephone EE-8-(*) through a 10,000-ohm resistance. The drops of the microphone and auxiliary circuits should also operate when the 0.5-*u*f capacitor is introduced in the drop circuit by placing the corresponding keys in the upward position. Check to see that the operation of all drops places a ground on the alarm circuit.

b. Ringing Circuit.

The ringing is effected by means of two mutually interrupting relays which operate from the 24-volt battery at the rate of 16 to 22 interruptions per second. This rate should be maintained. Regulate it by varying the tension of the relay spring with the tools furnished in Tool Equipment TE-37. Also, take care that the ringing relay (that is, the relay which connects two taps of the ringing transformer alternately to the 24-volt supply) is in the operated position

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about the same length of time that it is in the non-operated position. This can be checked visually, when the relays are operating, by observing the relative brightness of the movable springs as they appear stationary in both positions at once.

13. CONTROL BOARD BD-85-(*).

See paragraphs *9a, 9b, and 9c* for cord connections, batteries, and fuses, respectively, for Control Board BD-85-(*).

14. OSCILLOGRAPH EQUIPMENT IE-14-(*).

a. Optical System.

The optical system for Oscillograph Unit M-166-A consists of the recording lamp, the lens on the face of the oscillograph unit, the mirror on the suspension, and the cylindrical lens on the camera. The length of the optical path between the recording lamp and the photographic paper is fixed. Adjust the position of the cylindrical lens by turning the lens mounting screws at the front of the camera. This position, however, is critical, has been accurately set, and should not require readjustment. To gain access to the lens for cleaning, lossen the front plate locking screw and drop the plate forward.

b. Recording Lamp.

The recording lamp has a base of the pre-focus type to insure that the lamp will remain firmly in position and that a new filament will occupy, within very close limits, the same position as the old filament when a recording lamp is replaced. To insure good photographic records of the filament trace, make these three adjustments on the recording lamp mount:

(1) First loosen the locking nut and rotate the lamp socket. Rotation is on a longtiudinal axis passing through the filament, so that the position of the filament is not changed. Rotation selects that position of the lamp which eliminates secondary light sources, and thus prevents the formation of ghost images on the photographic paper.

(2) The lamp may be rotated on an axis at right angles to and passing through the center of the filament. This makes it possible to adjust the filament accurately to the vertical position necessary to

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obtain thin sharp traces on the record. Check the adjustment by viewing the points of light on the photographic paper through the peep-hole provided in front of the camera. The best adjustment is attained when these points are as small as possible.

(3) The vertical translation of the lamp is done by operating a rack and pinion arrangement at the left of the recording lamp housing. This provides for rapid vertical adjustment of the group of light images with respect to the camera lens and the viewing mirror, by changing the angles of incidence and reflection of the light beam at the mirror of the oscillograph unit.

c. Oscillograph Unit M-166-A.

(1) Eight of these units are assembled in a common galvanometer magnet (fig. 4), and each is connected to a sound channel by a Cord CD-475. The assembly is permanently mounted on Oscillograph Euipment IE-14-(*). Do not remove the individual elements except for replacement of mirror adjustment. Keep the lens, mounted at the front of each oscillograph unit, free from dust.

(2) The position of the galvanometer assembly is permanently fixed to give properly focused images at the photographic paper. All images should be equally spaced, sharp, in the proper order, and of approximately the same length. The vertical positions should be the same within ⅛ inch. About one-third of each image should fall on the viewing screen, the other two-thirds should be projected on the recording lens of the camera. The positions of the viewing screen and the elongated mirror are so adjusted that when sharp and properly spaced images are formed on the viewing screen, sharp and properly spaced lines will also be made on the record. However, if this is not the case, readjust the elongated mirror and the viewing screen to their normally correct positions.

(3) Routine adjustment has been provided only for the spacing of the images by rotation of the suspension. To do this turn the slotted pin at the top of the element with a screw driver. Adjustment of the vertical position should ordinarily not be necessary because the oscillograph units, as supplied, are properly aged and adjusted. However, should readjustment be necessary, as when a unit requires replacement, carefully bend the mirror support so that the vertical tilt of the mirror is changed. Proceed as follows:

(*a*). Disconnect Cord CD-475.

(*b*). Loosen the three thumbscrews holding together the galvanometer assembly.

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(*c*). Insert the tip of a screw driver in the space between the unit and the magnet at the rear of the assembly and pry that end of the unit loose from the magnet. With this end free from contact with the magnet, pry the front end loose with the screw driver. The unit may then be removed from the assembly.

NOTE.—When making adjustment for vertical position, it is advisable to remove only one oscillograph unit at a time from the assembly. Replace each adjusted unit before another is removed. As many as four units may be removed at any one time. Should it become necessary to remove more than four units, first place a soft iron keeper across the magnet to prevent partial demagnetization.

(*d*). Remove the dust cover, and place the unit on the pins at the side of the magnet. The unit is now in line with the other units in the assembly.

(*e*). Rotate the recording lamp housing until light falls upon the mirror of the unit. Rotate the suspension until the image is very close to the other images. The unit is now ready for adjustment. With a pair of brass tweezers, grasp the mirror support carefully, and bend until the tilt of the mirror is such that the reflected image is vertically in line with the others. Remove the unit from the pins, replace the dust cover, and install the unit in the galvanometer assembly. Reset the recording lamp cover to its normal position, and rotate the suspension of the unit until its image is properly spaced with respect to the others.

(*f*). Adjust the tension on the suspension with the small screw at the bottom of the unit. Turning the screw to the right increases the tension by stretching the small coil spring to which the lower suspension of the moving system is attached. Tension should be the minimum required for stability, i.e., just enough to keep the moving system from "swaying" when the oscillograph assembly is gently rocked.

d. Timing Unit.

(1). *Tuning Fork.*—Adjust the tuning fork driving contact so that the unit is self-starting when the circuit is closed after the tuning fork comes to a complete rest. The time motor driving contact must be barely open when the tuning fork is at rest. With these adjustments the frequency of the tuning fork will be 100 cycles per second, to within 1 part in 2,000.

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(2). *Time Lamp.*—Adjust the position of the time lamp and reflecting mirror so that the light from the time lamp passing through the largest slot of the time wheel falls squarely on the recording lens of the camera.

(3). *Time Wheel.*—Adjust the time wheel and the two-spoke wheel so that once in every 10 revolutions of the time wheel the large spoke of the two-spoke wheel obliterates all light that otherwise would pass through the largest slot of the time wheel, without obliterating the light that passes through the two adjacent small slots. Adjust the length of the small spoke of the two-spoke wheel so that once every 10 revolutions of the time wheel one-half of the largest slot in the time wheel is in shadow, and the light that otherwise would pass through this part of the slot is obliterated. The time wheel is not self-starting and should be started by turning the starting knob to the right.

e. Identification Panel.

(1). *General.*—The identification panel consists of the counter and the clock. The clock is of the 8-day type stem-wind and stem-set. The face has a 24-hour dial. Close the cover during non-operating periods to prevent the entrance of dust. Illumination for photographing is provided by four Lamps LM-30.

(2). *Identification mirror and lens.*—Clean the identification mirror and lens with ether and soft cotton. They should be so adjusted that a complete, sharp image of the identification panel is projected on the recording paper. In making this adjustment, the image of the identification panel may be observed on a short strip of recording paper inserted in the top part of the camera.

f. Camera.

(1). *Motor.*—The camera motor is of the governed type. The governor is mounted at one end of the motor shaft and the speed of the motor is controlled by rotating the governor head. Rotating to the right *decreases* the motor speed. Adjust the motor speed so that the linear speed of the film is approximately 6 inches per second.

(2). *Feed rollers and cutter.*—Make certain that the cutter is free of any paper that may have accumulated in the knurling of the roller. When the cutter is in the released position, the fixed feed roller should take a firm grip on the recording paper. In the oper-

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ated position of the cutter, the idle roller should clear the recording paper, and, on release of the cutter, should not engage the paper before the movable slot with the movable cutting blade has cleared the fixed cutting blade. The cutter should operate cleanly and crisply. If failure occurs, install a complete new cutter assembly. A spare feed roller is furnished with each Sound Ranging Set GR-3-C. The backstop of the cutter and the position of the solenoid relative to its plunger may be adjusted. These adjustments may be made by removing the protecting cover on the front side of the camera.

(3). *Developing roller.*—The recording paper should be firmly and symmetrically held by both edges of the developing roller. If the developing roller appears to be unsymmetrically located with respect to the feed mechanism, its position on the shaft may be shifted. To do this, remove the side wall of the camera and loosen the set screw.

(4). *Pick-up mechanism.*—The ends of the two teeth of the pick-up scoop should be well below the surface of the developing roller, and should clear all sides of the grooves of the developing roller in which they are located.

(5). *Light shield.*—The light shield that fits over the exit of the camera and the fixing tray, should be in place during recording to prevent fogging of the record by stray light.

(6). *Developing tray.*—Insert the rubber stopper, with the rubber tubing connected to the funnel securely in the drain hole of the developing tray, before filling the tray with the developing solution. The maximum which the tray can hold safely is 12 ounces. The level of the developing solution should always be kept between ½ and 1 inch from the top of the tray.

(7). *Developing solution and heaters.*—(*a*) The developing solution is made up of three parts of "A" solution and one part of "B" solution (Table I). The "A" and "B" solutions may be prepared in advance, but should not be mixed until just before using.

(*b*) This developer works best at temperatures of 65°F. and higher. The solution should not be allowed to go below 60°F. A heater is provided under the developing tray to keep the developer at a favorable working temperature in cold weather. Another heater is provided near the camera lens to prevent fogging of the lens when the developing solution is heated.

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DEVELOPING SOLUTIONS

"A" SOLUTION

Component	*Parts by weight*	*Suggested mix* * *
* "Elon" (paramethylamino-phenol sulfate)	1	38 grams (or 1⅓ oz.)
Sodium sulfite	20	756 grams (or 1 lb. 10⅔ oz.)
Hydroquinone	3	114 grams (or 4 oz.)
Water	300	3 gal.

* Put up under trade names of "Metol," "Pictol," and "Photol."

** 1 oz.=437.5 grains=28.4 grams.
1 gal. of water=8⅓ lb. avoirdupois.

"B" SOLUTION

Component	*Parts by weight*	*Suggested mix*
Sodium hydroxide	5	189 grams (or 6⅔ oz.)
Water, cold	100	1 gal.

CAUTION.—Sodium hydroxide and its solution is a strong caustic. Do not allow it to touch the skin or eyes, as it will cause severe burns. It will also destroy clothing. When preparing the solution, use cold water, add the sodium hydroxide slowly, and stir the solution continuously, as heat is evolved.

(*c*). The formula given has been proved satisfactory, but departures from it may be made by experienced personnel, if other formulas are found more advantageous. Use of other formulas will depend upon such considerations as: temperature, appearance of the finished records, preservation of the records, etc.

(8) *Fixing solution.*—The formula in Table II is recommended for the fixing solution. This solution should be used in the fixing tray with a dash of acetic acid to stop development immediately and prevent fogging of the record when it becomes exposed to light as it emerges from the fixing tray. The paper is then only partially fixed and should be allowed to stay for a few more seconds in the

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hypo tank attached to the table top behind the camera. Have a bucket of water available for washing the completed records. The film drier is used to squeeze excess water from the record. If time is a consideration, some alcohol may be used to rinse the finished records in order to hasten drying. If records are to be kept for some time, re-immerse them in a fixing solution for approximately 10 minutes, then immerse in water for approximately 20 minutes.

FIXING SOLUTION

Component	*Parts by weight*	*Suggested mix**
Sodium thiosulfate (hypo)	8	4536 grams (or 10 lb.)
Ammonium chloride	1	557 grams (or 1 lb. 3⅔ oz.)
Water	20	3 gal.

* 1 oz.=437.5 grains=28.4 grams.

* 1 oz.=437.5 grains=28.4 grams.

1 gal. of water=8⅓ lb. avoirdupois.

15. RELAY UNIT BK-9-(*).

a. After it has been ascertained that the recording system functions properly, test Relay Unit BK-9-(*) either by closing the outpost circuit or by placing the test key of Control Board BD-85-(*) on OVER-ALL TEST. When the outpost circuit is used, first check the outpost relay.

b. The proper sequence of operations controlled by Relay Unit BK-9-(*) between the closing and opening of the outpost circuit, is as follows: (check these operations against the wiring diagrams of Relay Unit BK-9-(*) (fig. 16), Control Board BD-85-(*) (fig. 19), and Oscillograph Equipment IE-14-(*) (fig. 17)).

(1) Outpost Relay AQA-1 operates quickly.

(2) A ground is placed on the control-board alarm circuit.

(3) The counter of the identification panel operates.

(4) Starting relay AQA-2 operates quickly.

(5) The cutter solenoid circuit is broken. (It is already open at the "make" springs of relay ASO-6.)

(6) The identification lamps are turned on, and the exposure of the identification photographs begins.

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(7) Voltage is supplied to the microphone circuits.

(8) Vibrating reed relay AVR-3 is energized and operates quickly.

(9) Motor relay ASO-4 is energized and operates after a delay of .1 to .3 second.

(10) The identification lamps are turned off, thereby terminating the exposure of the identification photograph.

(11) The camera motor starts.

(12) Weighted spring relay AWS-5 is energized and its armature pulls up quickly.

(13) After the vibrations of the weighted spring of relay AWS-5 have died down, in about 1 second, lamp relay ASO-6 operates.

(14) The cutter solenoid circuit closes at this point, but is still open at relay AQA-2.

(15) The time lamp (24 volts) and the recording lamp (6 volts) are turned on.

(16) From this time on, the recording operation takes place until the outpost circuit is opened.

c. When the outpost circuit is opened, the following sequence of operations takes place:

(1) Outpost relay AQA-1 is de-energized and releases quickly.

(2) The control board alarm circuit is opened.

(3) The counter relay is de-energized and releases.

(4) Starting relay AQA-2 is de-energized and releases quickly.

(5) The cutter solenoid circuit is closed and the cutter operates.

(6) The microphone circuits are switched from the 90-volt battery to ground.

(7) Vibrating reed relay AVR-3 is de-energized and its released vibrating reed keeps motor relay ASO-4 operating for a few seconds.

(8) Motor relay ASO-4 is de-energized and releases.

(9) The camera motor stops.

(10) Weighted spring relay AWS-5 is de-energized and releases quickly.

(11) Lamp relay ASO-6 is de-energized and releases.

(12) The cutter solenoid circuit is opened and the cutter releases.

(13) The time and recording lamps are turned off.

d. If Relay Unit BK-9-(*) does not function properly because of relays' operating or releasing too quickly or too slowly, or because of damaged contacts, use the tools of Tool Equipment TE-37 to adjust the relay spring tension or to clean the contacts. Take care

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to adjust the tension of the movable relay springs. To do this, bend the springs near the base and follow through with the tool up to the spring contact to give the spring a distributed tensioning. The quality of the work done can always be gauged from the straightness of the adjusted spring, along its edge. This work should normally be performed by someone who has received proper training in relay adjustment and care.

e. When motor relay ASO-4 is adjusted, the relay should be energized strongly enough to operate the two break contact springs and the three make contact springs. The time delay of motor relay ASO-4 may also be adjusted by means of the 200-ohm rheostat mounted on the relay mounting base. This adjustment may be changed from time to time to take care of variations in the 24-volt supply or in the effectiveness of the developing solution in developing the identification photograph.

f. The time delay of lamp relay ASO-6 in combination with weighted spring relay AWS-5 should be just sufficient to allow the identification photograph to pass by the recording lens of the camera. The extent of the delay is related to the position of the outpost with respect to the first microphone reached by the gun report.

g. Adjust vibrating reed relay AVR-3 to allow sufficient time for the record to leave the camera before the camera motor stops.

h. Make all these adjustments with Relay Unit BK-9-(*) in an upright position—its normal position when properly mounted in Control Board BD-85-(*).

16. PROTECTOR AR-8.

Protector AR-8 constitutes the terminal part of the line installation and should be located on a pole or on a tree, if possible. Make certain that its fuses and spark-gap blocks are in good order. Each fuse should show a closed circuit and each spark-gap an open circuit when tested with an ohmmeter.

17. MICROPHONE EQUIPMENT.

a. Microphone T-21-(*).

Test each Microphone T-21-(*) before and after it is installed on the field array. To test before installation, proceed as follows:

(1) Connect the microphone, equipped with tubes and batteries,

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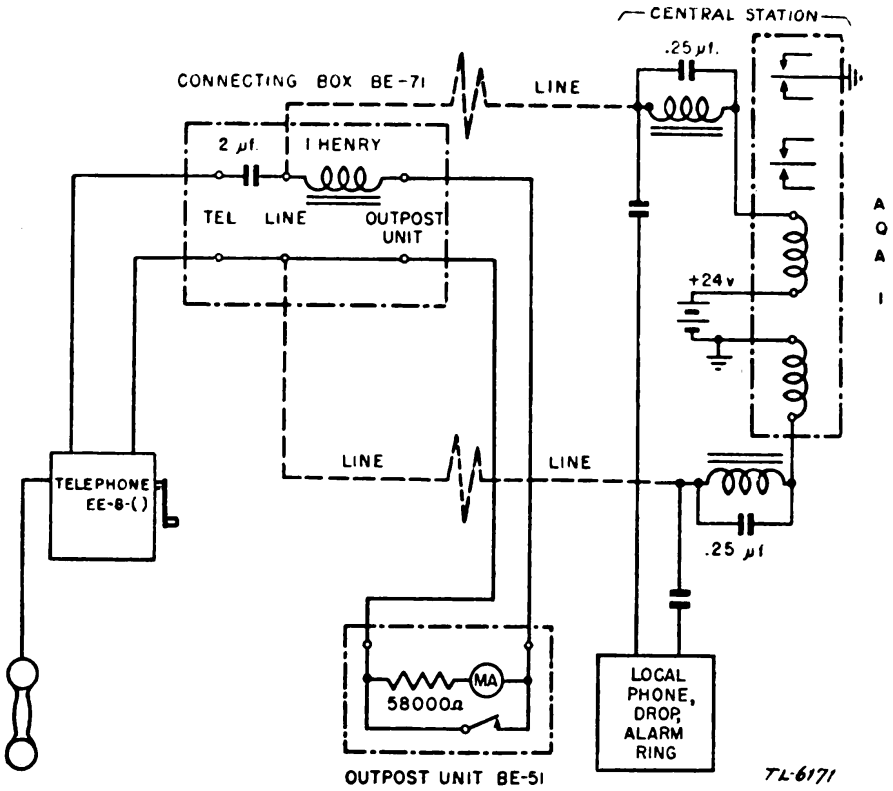

Figure 11.—Outpost wiring diagram.

to the oscillograph assembly through the switchboard and control board, in place of one of the incoming lines.

(2) With the test key of Control Board BD-85-(*) placed on CIRCUIT TEST, the milliammeters should each read approximately 4 milliamperes. If the polarity of the connection between microphone and control board is incorrect, the milliammeter will read approximately 2 milliamperes.

(3) The polarity is corrected by reversing the hammer-head plug of Cord CD-428.

(4) When a gust of air is produced near the outside plug of the microphone, the control board milliammeter of the circuit used oscillates over 1 or 2 milliamperes while the corresponding recording light image oscillates more or less violently (depending upon the potentiometer setting). Both milliammeter and light image should be very quiet whenever the holes in the outside plug of the microphone are kept closed.

(5) Repeat the test outlined above after the microphone has been installed.

(6) Co-ordination between the oscillograph operator and the installation crew is made by telephone communication over the

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microphone line. If the recording equipment assembly is not available for this test, the 5-milliampere scale of the voltohmmeter may be used in place of the milliammeter of Control Board BD-85-(*) to indicate oscillations of current. In this case a 90-volt dry cell battery will be required to supply plate voltage to the microphone amplifier.

b. Protector AR-4.

The protector should be connected between Microphone T-21-(*) and the line.

c. Microphone Shelter BE-66-A.

The assembly of Microphone T-21-(*) and Bag BG-97 should be installed in a round hole dug in the ground, sufficiently wide and deep to prevent any contact between the assembly and the earth. Microphone T-21-(*) must be suspended from the two springs of Microphone Shelter BE-66-A, and the shelter merely laid over the opening of the hole. Pile some earth smoothly around the shelter to eliminate openings under the edge and to eliminate obstructions in the path of the wind that might cause pressure gusts.

CAUTION:—Do not place the microphone within 100 yards of a gun as the blast from the gun may damage the microphone.

18. OUTPOST EQUIPMENT.

Connect the line, the telephone, and Outpost Unit BE-51 to Outpost Connecting Box BE-71, as indicated in figure 11. This figure is also shown on the top plate of the outpost connecting box.

19. PRELIMINARY OVER-ALL TESTS.

a. Over-All Response Test.

An overall frequency response test of a complete channel may be made with the use of Chest CH-40-(*).

(1) Place the microphones, equipped with tubes and batteries, in the chest.

(2) Connect the lead wires in the chest to the proper microphone terminals and clamp the lid of the chest shut.

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(3) Connections are made from the terminal board of the chest to the recording equipment assembly.

(4) Check and correct polarity as in paragraph 17*a*.

(5) Set the attenuators at 6.

(6) Set the pistonphone in motion by quickly pulling up a string which has previously been wound around the fly-wheel shaft. Make a photographic record for the full frequency range provided by the pistonphone. With the attenuators of all the channels adjusted to equal settings, the excursions of the traces should be approximately the same at any frequency.

b. Circuit Test.

When all microphones have been installed, test the proper functioning of the microphones, the control-board equipment, and the oscillograph unit by placing the test key of the control board on CIRCUIT TEST. The microphones are thereby energized, and the recording lamp is turned on. If all these parts function properly, a characteristic behavior of the microphone milliammeters will be observed on the control board, and the light images on the viewing screen will indicate wind-pressure gusts at the various microphone positions.

c. Over-All Test.

Place the test key on OVER-ALL TEST. The set should operate and produce a record, just as though the outpost circuit had been closed, except that the counter of the identification panel will not advance and the alarm circuit will not be closed.

d. Outpost Test.

Make sure that telephone communication with the outpost operator is available. The outpost operator should also operate Outpost Unit B-51 at the request of the oscillograph operator to ascertain whether the outpost circuit is functioning properly. It should be possible to maintain telephone communication with the outpost operator whether the outpost circuit is closed or not.

20. OPERATION.

a. Oscillograph.

Control Board BD-85-(*) and Oscillograph Equipment IE-14-(*) are turned on by means of the STATION BATTERY switch.

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As soon as the tuning fork is vibrating, start the time wheel by hand by rotating the starting knob to the right.

b. Switchboard BD-62-(*).

Switchboard BD-62-(*) has been designed for use either with Handset TS-9-(*), or with the combination of Head Set HS-30-(*) and Chest Set TD-1. Both of these can be used by connecting one set to Plug PL-58 and the other to terminals *T*, *C*, and *R* on the switchboard. Telephone communication with the outpost operator or operators should be maintained at all times. Personnel assigned to the microphone stations or to the maintenance of the lines can establish telephone communication with the oscillograph if they are equipped with a Telephone EE-8-(*).

c. Outpost.

With the sound ranging set properly installed and adjusted, the taking of records can be controlled entirely from the outpost by the operation of Outpost Unit BE-51. A record is started when the outpost operator presses the button switch of Outpost Unit BE-51. At the same time the alarm buzzer in the switchboard operates to warn the oscillograph operator that recording has started. Also, the outpost operator can transmit a verbal "on the way" signal over the telephone. The outpost operator can control the duration of recording by keeping the button switch on Outpost Unit BE-51 pressed until he judges the sound report has reached all the microphones. With the button switch on Outpost Unit BE-51 closed and the test key on Control Board BD-85-(*), (in the neutral position), the alarm buzzer will continue to operate. As soon as a record has been started, the recording can be taken over by the oscillograph operator. He does this by switching the test key to OVER-ALL TEST. This operation opens the circuit of the alarm buzzer and also permits the outpost operator to release the switch on Outpost Unit BE-51. The oscillograph operator will observe the behavior of the light images on the viewing screen, and stop the recording by switching the test key to NEUTRAL when his observation indicates that the sound has reached all microphones. If, in the meantime, the switch on Outpost Unit BE-51 has again been placed in the pressed position, the recording will continue and the alarm buzzer will again begin to operate as a signal to the oscillograph operator that another sound report is "on the way." Any characteristic features of the sound heard by the outpost operator can be telephoned to the oscillograph operator.

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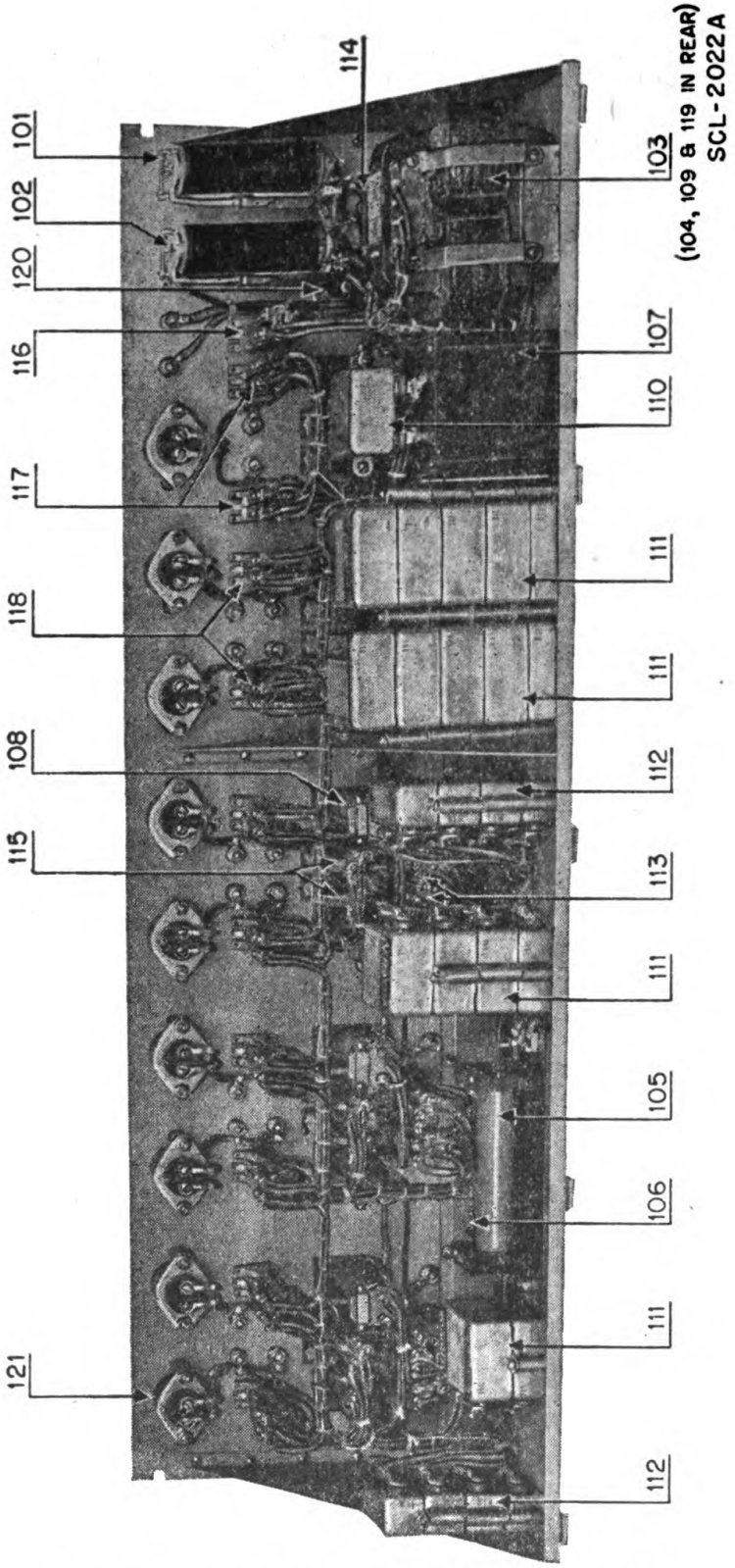

Figure 12.—Switchboard BD-62-(*), rear view.

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Section III

FUNCTIONING OF PARTS

	Paragraph
Switchboard BD-62-(*)	21
Control Board BD-85-(*)	22
Relay Unit BK-9-(*)	23
Oscillograph Equipment IE-14-(*)	24
Oscillograph Unit M-166-A	25
Microphone T-21-(*)	26
Protector AR-8	27
Cord CD-250-A	28
Outpost equipment	29

21. SWITCHBOARD BD-62-(*).

a. Switchboard BD-62-(*) (figs. 1, 12, and 13) provides means for conveniently switching or patching the various incoming outpost or microphone lines for communication and testing purposes. The switchboard has 1 telephone circuit and 10 other circuits as follows: 2 outpost circuits and 8 microphone circuits.

b. The input connections to the 10 switchboard circuits are made by means of 10 pairs of binding post terminals located along the bottom of the operating panel. Each circuit has two jacks, a telephone drop, and a key. A pair of binding posts and a socket for Cord CD-428 are provided at the output end of each microphone circuit. The two outpost circuits have a common output which is terminated in a pair of binding posts and a socket for Cord CD-428. The circuits in Switchboard BD-62-(*) are normally connected to the corresponding circuits in Control Board BD-85-(*) by means of Cords CD-428, but the connection can also be made by jumper wires between the corresponding binding posts on the switchboard and control board. To change the polarity of connection to the microphone line, reverse the hammer-head plug on Cord CD-428 in the socket at the switchboard. Plugs on Cords CC-66 or CC-67 fit into the switchboard jacks. Plugging into the upper jack connects across the circuit established with the incoming line, and plugging into the lower jack connects to the incoming line, cutting out the local circuit. The telephone drops indicate the ringing of the corresponding line, and operation of any one of the drops places a ground connection on the alarm circuit, thereby operating the

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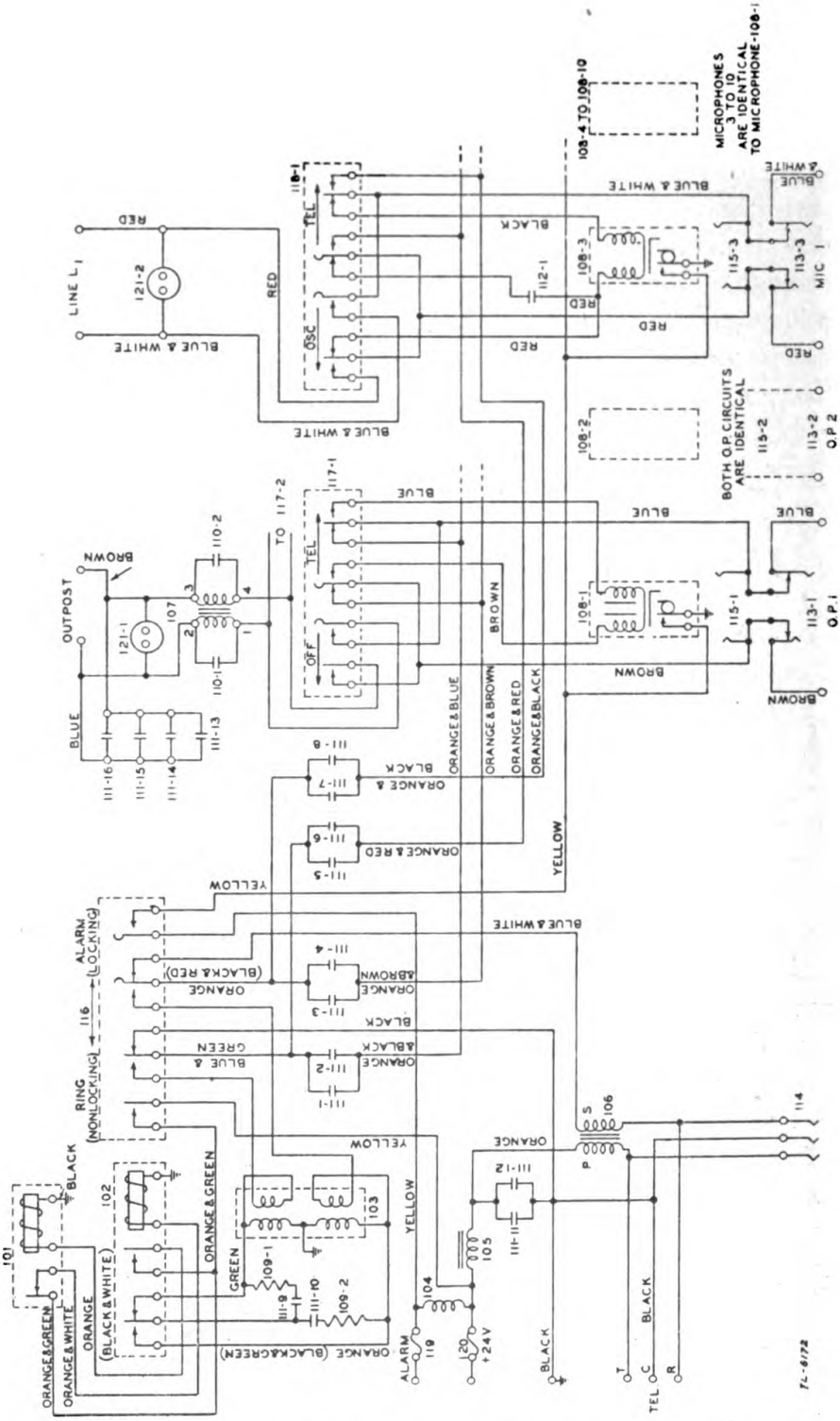

Figure 13—Switchboard BD-62-(*)—circuit diagram.

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buzzer in the switchboard. The night alarm can be installed between the +24V binding post and alarm binding post.

c. The keys permit three connections for the *outpost circuit*:

(1) Key down—outpost line to indicator drop.

(2) Key normal—outpost line to telephone circuit.

(3) Key up—outpost line to telephone and control board outpost circuits.

d. The keys permit three connections for the *microphone circuits*:

(1) Key down—microphone line to telephone circuit.

(2) Key normal—microphone line to indicator drop.

(3) Key up—microphone line to control board microphone circuit and to indicator drop through a 0.5*u*f capacitor.

e. The 0.5*u*f. capacitors with the indicator drops in series have a high impedance, at sound-ranging frequencies (5 to 25 cycles per second), compared with the microphone circuits and do not alter the characteristics of these circuits. These capacitors permit passage of sufficient current to operate the indicator drops when properly adjusted. The outgoing or incoming ringing current on the outpost circuit is prevented from reaching the control-board outpost circuit by a choke coil. Two 0.25-*u*f. capacitors connected across the two windings of this choke coil increase the impedance of the coil at ringing frequency.

f. The telephone circuit consists of a talking circuit of conventional design, and a ringing circuit. The two relays of the ringing circuit are connected so as to be mutually connecting and interrupting when energized from the 24-volt supply. As the 24-volt supply is alternately connected to two taps of the ringing autotransformer, a ringing alternating voltage of approximately square wave form and 96-volt peak value on open circuit is generated at the terminals of the autotransformer.

22. CONTROL BOARD BD-85-A.

a. Control Board BD-85-A (figs. 1, 14, and 15) contains eight identical control circuits, one for each of the eight microphone circuits. Meters are provided for indicating the following currents and voltages:

(1) Plate current of each microphone circuit.

(2) Plate supply voltage for the microphone circuits.

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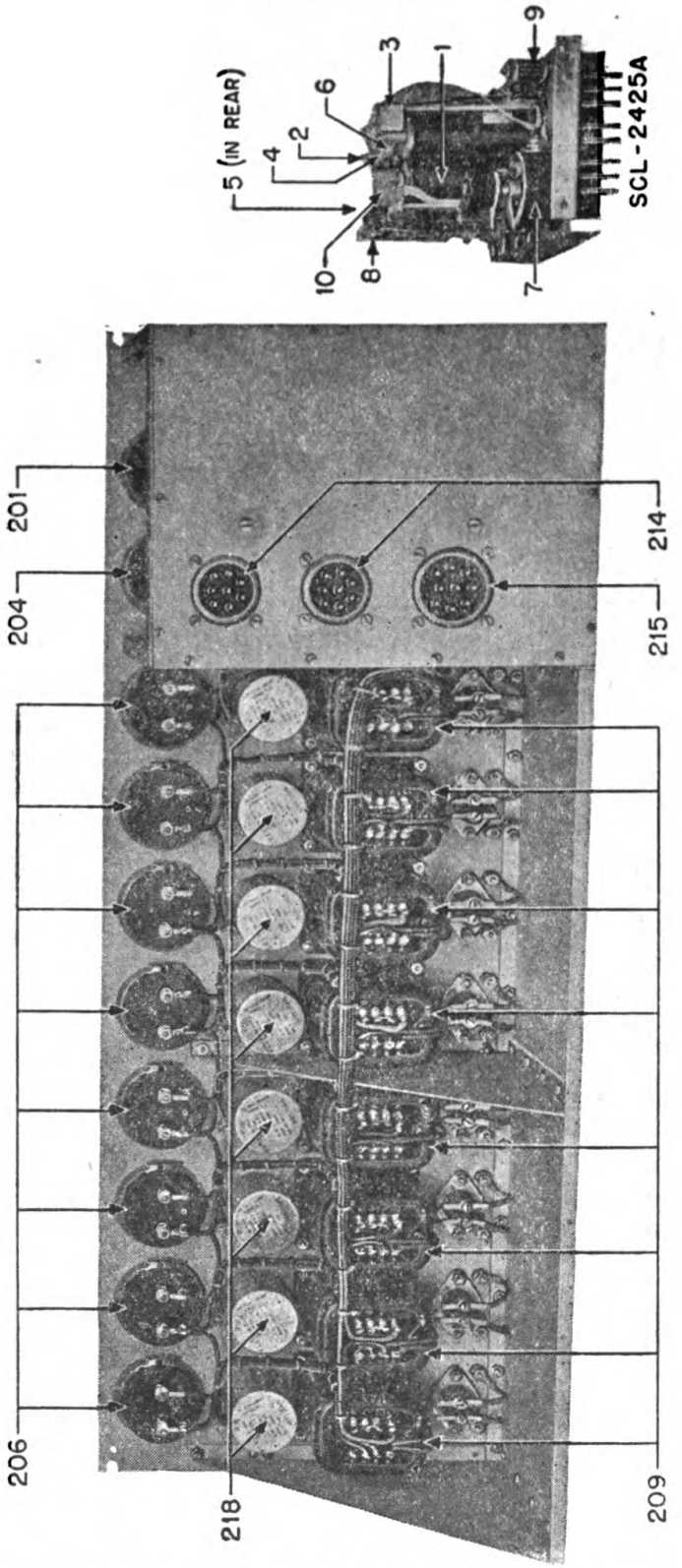

Figure 14.—Control Board BD-85-(*) (rear view) and Relay Unit BK-9-(*).

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(3) Recording lamp current.

(4) Station battery voltage.

(5) Total station battery current.

(6) Outpost circuit current.

Control Board BD-85-A also houses Relay Unit BK-9. This unit is connected to the circuits of the control board through a 16-point base plug that engages a 16-point frame jack mounted in the control board. Relay Unit BK-9 is readily removable through a door located at the left end of the control board.

b. Each of the eight control circuits of Control Board BD-85-A consists of a transformer and a ladder-type attenuator which couple the microphone to Oscillograph Units M-166-A. The transformer has a 31.6:1 turns ratio, and an input inductance of 200 henries, with 5 milliamperes flowing through the primary winding.

c. Each ladder attenuator has an approximately constant impedance of 10 ohms and is graduated in 16 steps of 3 db per step, the gain increasing clockwise. For a given input, an increase of two steps on the control setting will approximately double the amplitude of oscillation of the moving system of Oscillograph Unit M-166-A.

d. The meters are shown in figure 15, the schematic wiring diagram of Control Board BD-85-(*). The numbers encircled in the diagram refer to the connections of the three sockets at the rear of the control board. A wiring diagram similar to that of figure 15 will be found inside of the control board cover, mounted on the back plate.

23. RELAY UNIT BK-9-(*).

Relay Unit BK-9-(*) consists of six interconnected relays arranged to close and open various electrical circuits in a definite time sequence, thereby making possible the automatic operation of Sound Ranging Set GR-3-C. The operation of Relay Unit BK-9-(*) is outlined in section II, paragraph 15. One spare Relay Unit BK-9-(*), together with spare parts for servicing, is supplied with each Sound Ranging Set GR-3-C. A wiring diagram, similar to that of figure 16, will be found on the inside of the door at the left end of Control Board BD-85-(*).

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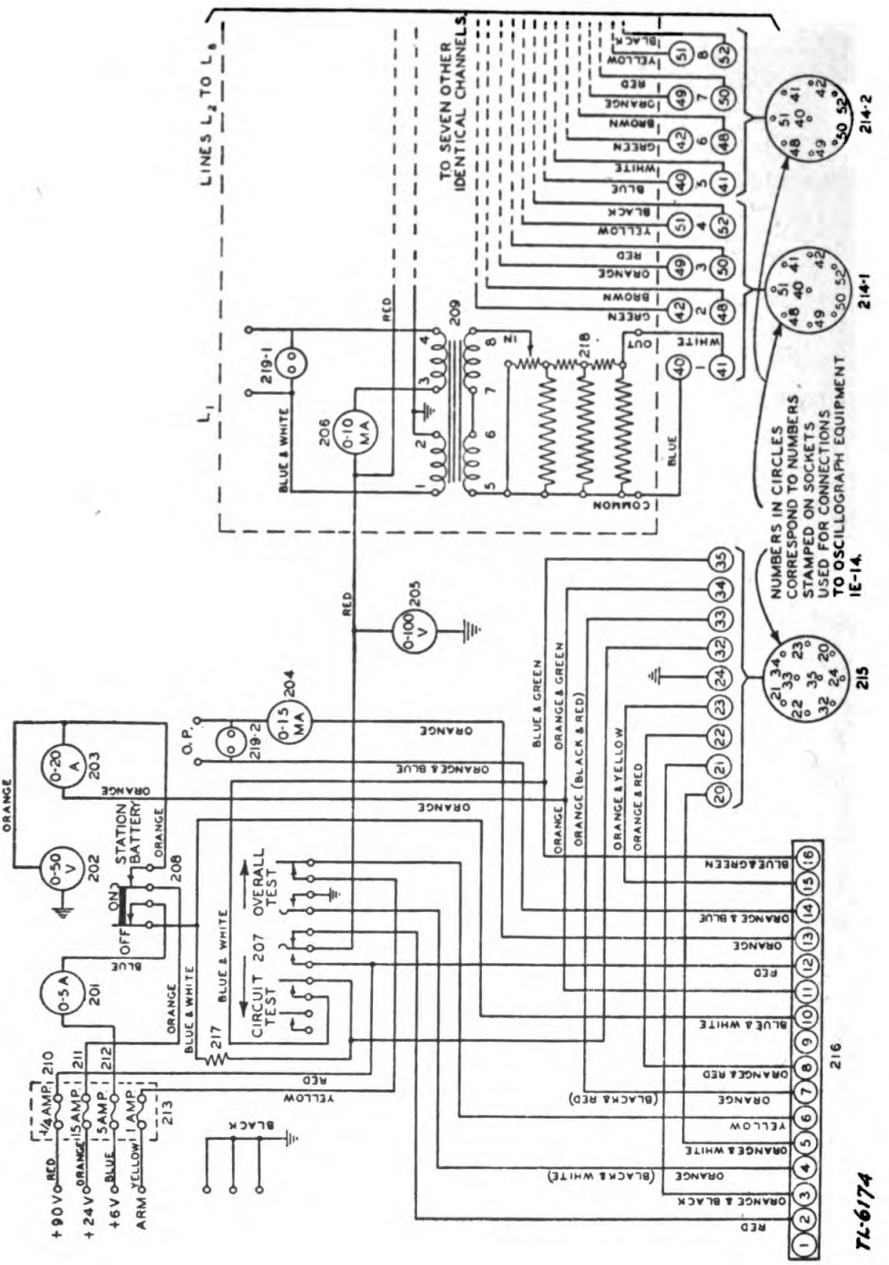

Figure 15.—Control Board BD-85-(*), circuit diagram.

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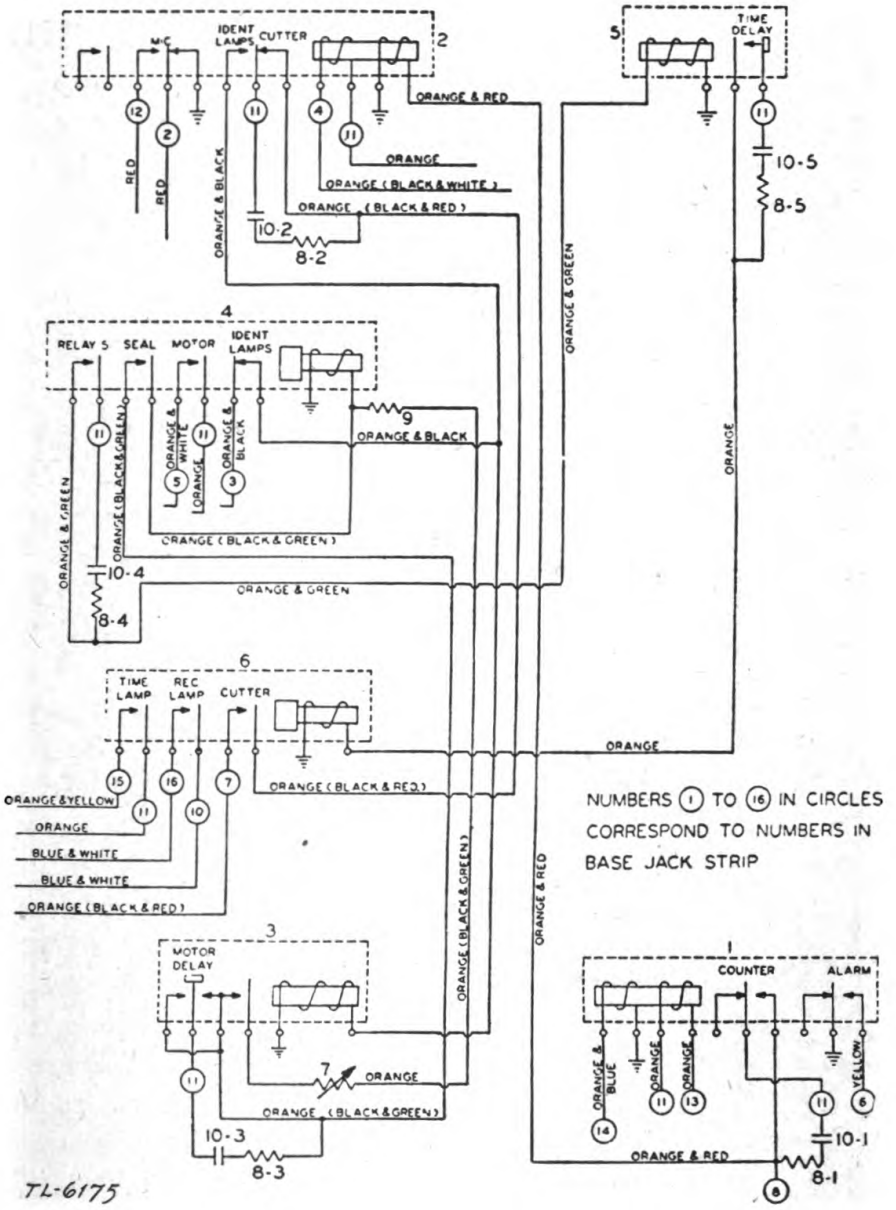

Figure 16.—Relay Unit BK-9-(*), circuit diagram.

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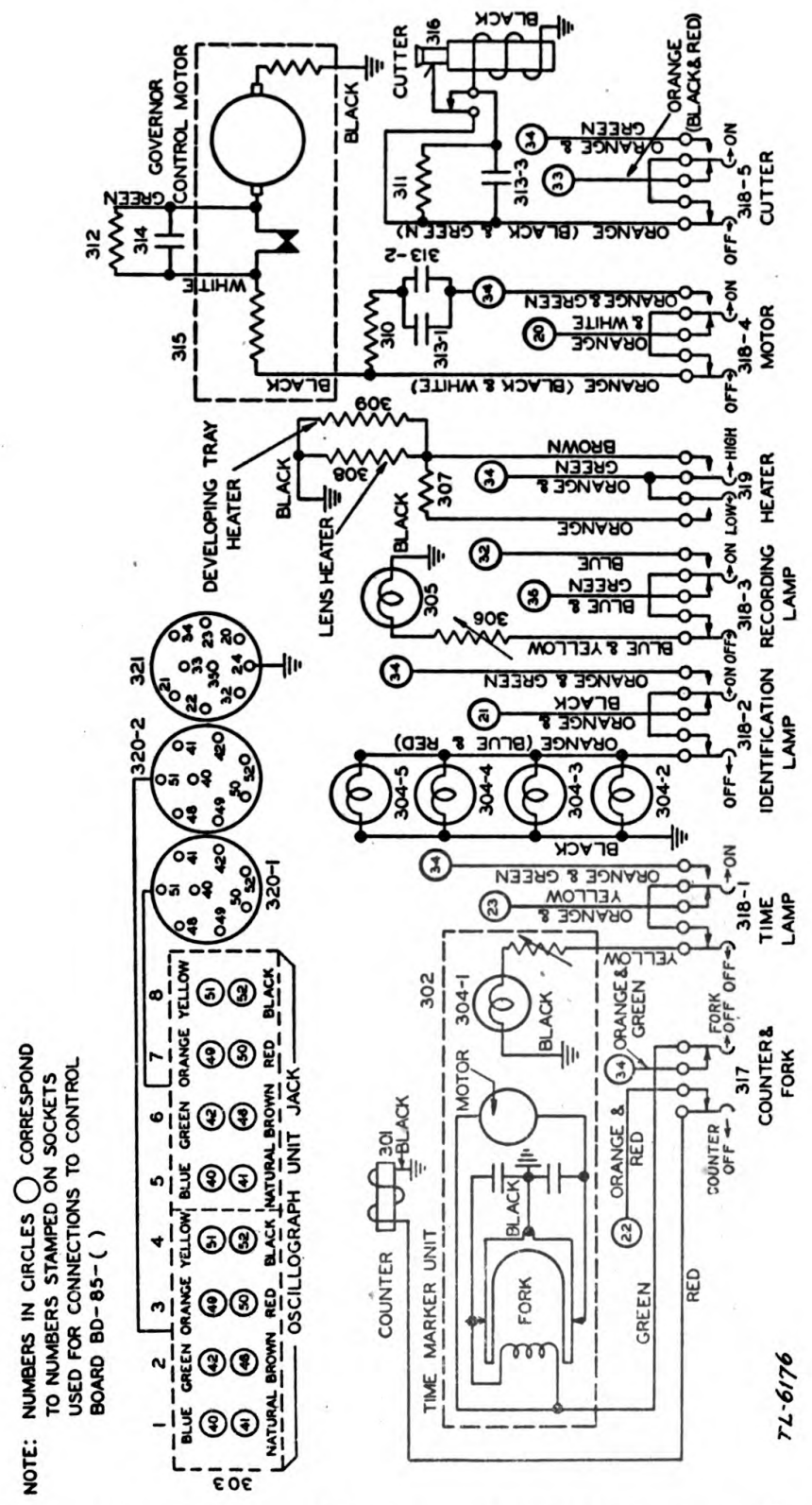

Figure 17.—Oscillograph Equipment IE-14-(*), circuit diagram.

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24. OSCILLOGRAPH EQUIPMENT IE-14-(*).

A wiring diagram is shown in figure 17. The circuit connections of this equipment are located under the table top, and access to them is obtained by removing Control Board BD-85-(*) and removing the bottom cover of the oscillograph equipment. A circuit diagram, similar to that of figure 17, will be found fastened to the removable panel on the large light hood of Oscillograph Equipment IE-14-(*). The various keys on the narrow front panel operate individually the components of the oscillograph equipment. See also section II, paragraph 14.

25. OSCILLOGRAPH UNIT M-166-A.

A photograph of this unit is shown in figure 4. It is of the moving coil type. A coil of fine copper wire is suspended in the air gap between two pole pieces built integral with the housing. A small mirror is mounted on a support that is fastened rigidly to the coil so that coil and mirror move together. This combination forms the moving system of the unit. The upper and lower suspensions are similar fine gold strips. One end of the upper suspension is fastened to the moving system, the other end to an insulated rotatable pin at the top of the housing. One end of the lower suspension is fastened to the moving system, the other end to a fine coiled spring, the tension of which can be adjusted by turning the screw in the bottom of the housing. The insulated terminals of the unit are connected to the output transformer of Control Board BD-85-(*) by means of Cords CD-475. When the unit is placed in position in the galvanometer magnet, a magnetic field is produced in the gap between the pole pieces. When current from the output transformer flows through the coil, a force is set up which causes the coil and its attached mirror to deflect in accordance with the magnitude and direction of the coil current, thereby causing a corresponding deflection of the light spot on the recording paper.

26. MICROPHONE T-21-(*). (Figs. 8, 18, and 19).

a. Microphone T-21-(*) is a combination condenser microphone and amplifier and a double Helmholz resonator. The condenser head of the unit is mounted at the top of the inner resonat-

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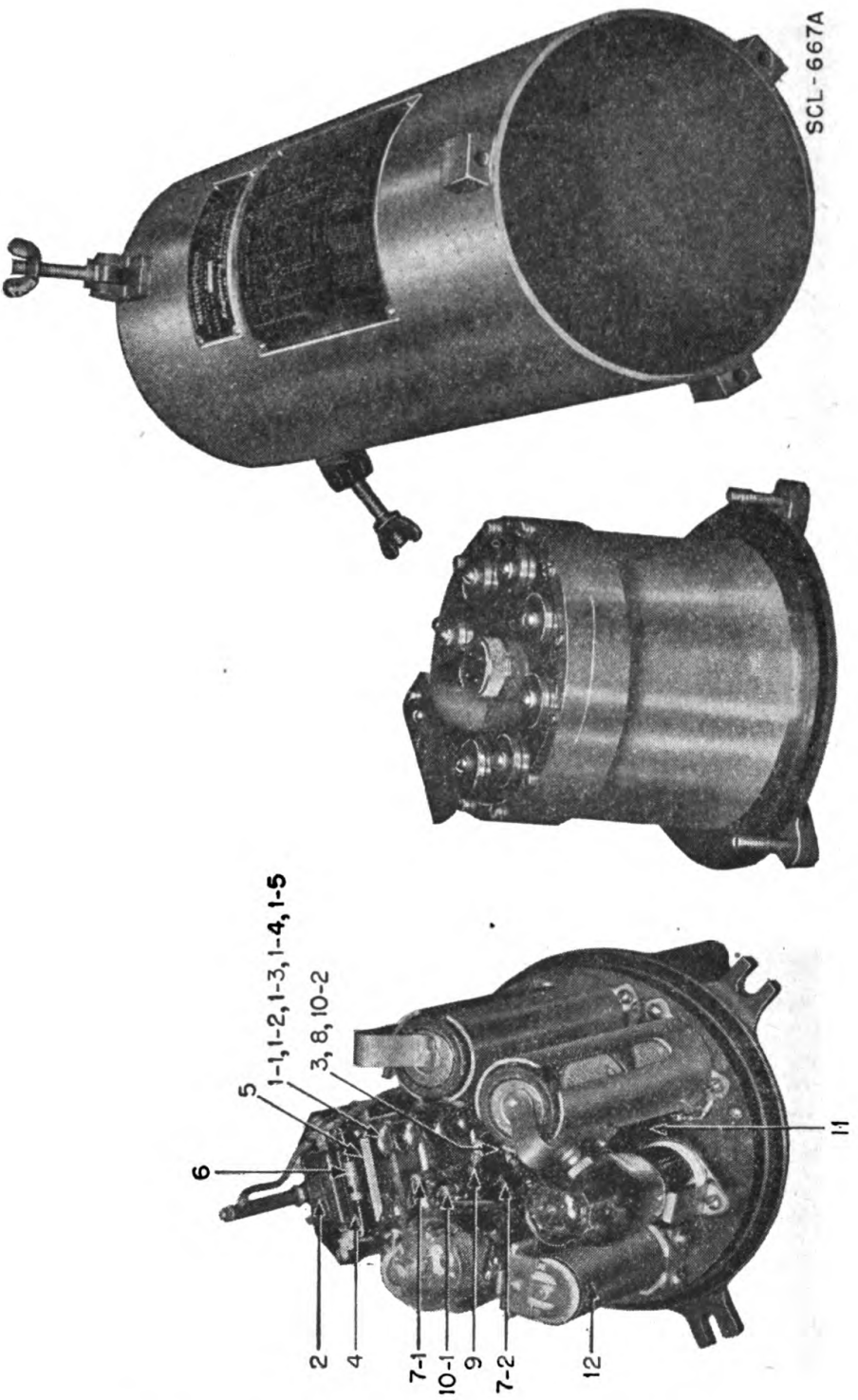

Figure 18.—Microphone T-21-(*)—disassembled.

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ing chamber, and consists of a thin stretched metallic diaghragm mounted symmetrically .004 inch from an insulated metal plate. Air pressure from the main chamber of the microphone reaches this inner chamber through the holes of a removable plug. Access of air pressure from the outside to the main chamber is through the holes of another removable plug. The combination of the two plugs and of the inner and outer chambers forms a two-section acoustical low-pass filter. The dimensions of the plug holes have been calculated to obtain a 25-cycle-per-second cut-off frequency for this filter.

b. The power supplied from the line to the microphone serves as plate voltage for the two amplifying tubes and as polarizing voltage for the condenser head, and also serves to energize the relay which turns on the local filament batteries. The plate of the output Tube VT-27 is placed directly across the line; the plate supply of the first Tube VT-44 is fed through a two-section resistance-capacitance filter. This voltage is further filtered to serve as polarizing voltage for the condenser head. The voltage amplification yielded by the first tube is between 40 and 50. A further voltage amplification of about 9 is yielded by the second tube.

c. Insulating Bag BG-97 is used to prevent earth grounds on the microphone case. The microphone line is ungrounded and since the case is connected to one side of this line, an earth ground of the case will unbalance the system and produce erratic excursions of the recorded traces. Bag BG-97 will protect the case even if the hole in which the microphone is suspended should become partially filled with water.

d. Protector AR-4 is connected to the microphone at its field position to protect the microphone from the effects of the discharge of static electrical charges accumulated by the line, or in the event that lightning strikes the line.

27. PROTECTOR AR-8.—(See par. 16).

28. CORD CD-250-A.

Cord CD-250-A is used to connect Protector AR-8 with Switchboard BD-62-(*). The cordage contains 15 pairs of conductors,

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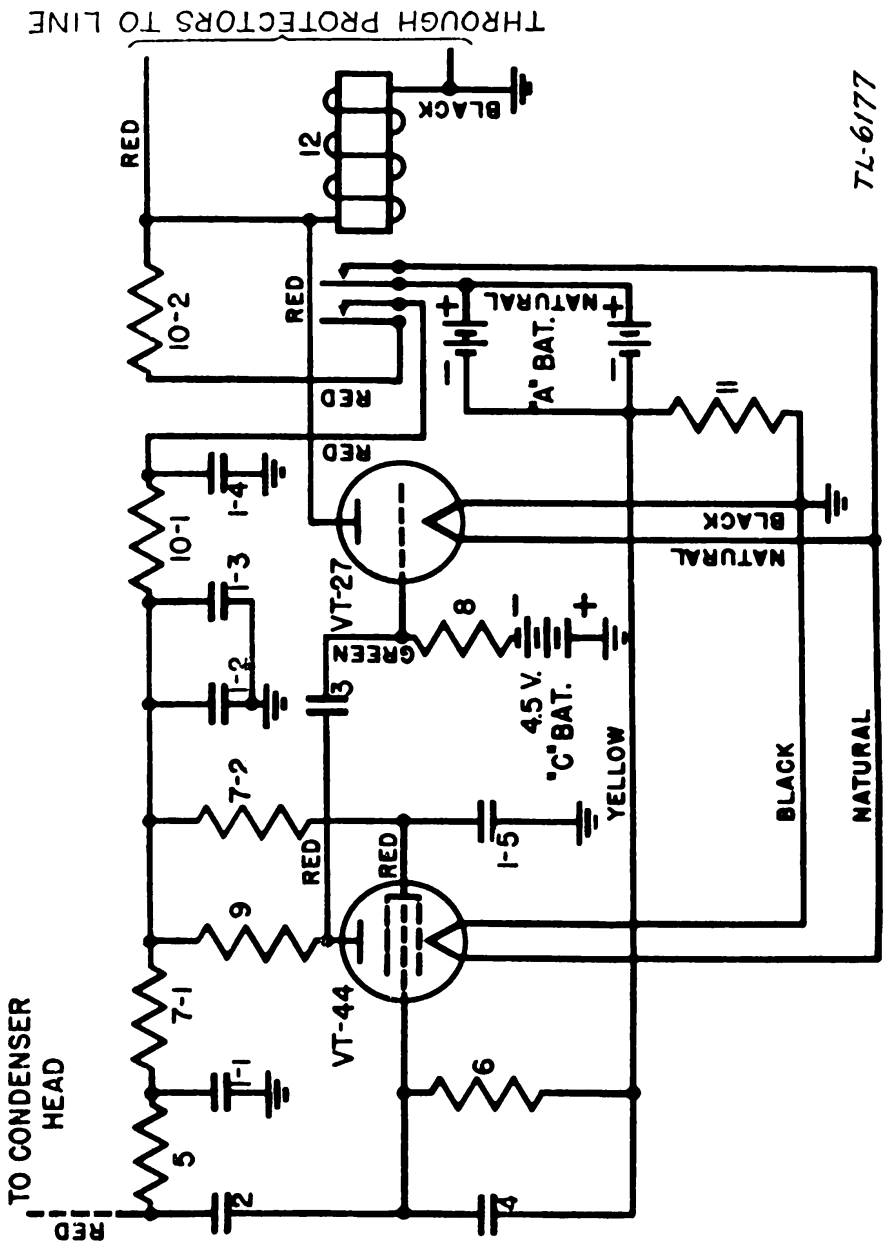

Figure 19.—Microphone T-21-(*), circuit diagram.

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of which only 11 pairs are normally used. One end of the cord is terminated in an 11-pair phenolic plug for quick connection to Protector AR-8. The eight microphone terminals are labeled MIC 1 to MIC 8; the two outpost terminals, O. P. 1 and O. P. 2; and the auxiliary, AUX 1. The four pairs of spare conductors are taped to the phenolic plug. At the switchboard end, the cordage is fanned out for connection to Switchboard BD-62-(*) (O. P. 1 and O. P. 2, and MIC 1 to MIC 8). The pair of conductors corresponding to auxiliary (AUX 1) on the phenolic plug is terminated in spade terminals and is 29 inches in length. This pair is wrapped and rubber-taped about the cordage for a distance of approximately 2 inches in the direction away from the switchboard. The four spare pairs of conductors, which are carried to the extreme end of the cord, looped back, and enlosed in rubber tape, are for repair of the cord, when necessary.

29. OUTPOST EQUIPMENT (figs. 10 and 11).

a. Telephone EE-8-(*).—See TM 11-333.

b. Outpost Connecting Box BE-71.

This component comprises three pairs of binding posts, a 2.0-*uf.* capacitor, and a 1-henry choke coil (C-158), and connects the outpost line to one Telephone EE-8-(*) and to one Outpost Unit BE-51. The capacitor is connected in the telephone circuit and the choke coil in the outpost unit circuit, thereby permitting simultaneous operation of the telephone and of the outpost unit.

c. Outpost Unit BE-51.

Outpost Unit BE-51 comprises a milliammeter in series with a 58,000-ohm resistor, and a switch. The ammeter with the series resistor is normally placed across the line, and the ammeter deflection serves as an indication to the outpost operator that the line is energized. The operation of the switch places a short across the line, thereby operating the outpost relay in the central station. The unit is housed in a leather carrying case with a celluloid window for observing the milliammeter. The switch, a push-button type, can be operated without removing the unit from its carrying case.

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Section IV

MAINTENANCE

	Paragraph
General	30
Care and cleaning	31
Circuits	32
Relays	33
Microphone T-21-(*)	34
Control Board BD-85-(*)	35
Relay Unit BK-9-(*)	36
Switchboard BD-62-(*)	37

30. GENERAL.

All repairs should be made by thoroughly competent personnel. *Don't use acid-core solder or soldering flux. Always use rosin-core solder.*

31. CARE AND CLEANING.

a. Batteries.

(1) *Storage batteries.*—For maintenance of the storage batteries, see TM 11-430.

(2) *Dry batteries.*—Inspect all dry batteries at least twice a month. This inspection should include testing for voltage and examining for mechanical defects, such as swelling, in order to prevent damage caused by leakage of electrolyte.

b. Vacuum Tubes.

Check all vacuum tubes at least once every 2 months by comparing their performance with the performance of fresh tubes.

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c. **Photographic Equipment.**

(1) Clean all photographic equipment thoroughly at the end of each "day" of operation.

(2) Drain the developer tray and fill it with 12 ounces of clean water.

(3) Run the camera for about ½ minute.

(4) Drain the tray again. This is done to clean the developer roller and developer tray of all chemicals. During the cleaning operation remove the recording paper magazine, or place the cutter switch at ON, so that recording paper is not wasted.

(5) Repeat the above operation until the drained solution is fairly clean.

(6) Disassemble and clean the camera thoroughly at regular intervals; otherwise, the accumulation of dirt and bits of paper will seriously affect its operation.

(7) Lubricate the camera periodically by placing a few drops of light oil in the oil holes located directly beneath the recording paper magazine. A small amount of oil should also be placed on the exposed shafts of the gear box and on the bearings of the fixing tray roller.

32. CIRCUITS.

If a circuit becomes defective, first inspect the wiring for loose connections. Check moving parts, capacitors, and coils. If no defect can be found in the individual parts, check the circuit step by step by means of Test Set I-56-C until the defect is found.

33. RELAYS.

Inspect the relays at least once a month. The adjustment or replacement of springs should be performed by personnel specially trained in relay adjustment and care. Standard adjustments are given in the paragraphs following.

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34. MICROPHONE T-21-(*).

The condition of the amplifier and the condenser head of a microphone can be checked by substituting parts of a microphone known to be in good condition, and comparing results. If a condenser head is faulty, the defect may be caused by a direct short in the condenser head, or by a faulty diaphragm. If it becomes necessary to change the diaphragm of the condenser head, clamp a square sheet of new diaphragm material securely in Clamp MM-7, and place it over the opened condenser-head chamber, the rim of which should be slightly oiled and free of grit or any other foreign particles. Place weights aggregating 30 to 40 pounds on the periphery of the clamp, or suspend them from the holes at the corners of the clamp. Two microphones with their amplifiers removed may be used for weights; suspend them from two opposite corners of the clamp. Dust the top face of the diaphragm carefully to remove any dust or other particles, locate the dowel pinholes by gently rubbing the rim of the chamber with an eraser. Place the head over the diaphragm and screw it down, taking care to tighten every fifth screw in turn, starting from any given screw. If the amplifier is at fault, check battery voltages under load, and install new batteries if necessary. Tubes known to be in good condition should be installed. The relay contacts may be cleaned and adjusted with Tool Equipment TE-37. With the microphone in operating position (handle up), adjust the amplifier relay as follows:

a. The armature should move freely on its bearing surface but must not be loose.

b. Set the residual adjustment screw to give not more than .001-inch clearance between armature and pole piece, when the armature is held firmly against the pole piece.

c. Turn the adjusting screw on top of the relay to obtain a clearance of .012-inch between the residual screw and the pole piece, when the relay is in normal position.

d. Place a .006-inch feeler gauge between the residual screw and the pole piece, holding the armature firmly against the gauge. Adjust the heavy contact spring so the contact is barely touching. This allows the armature to travel .006-inch while the contact makes after the feeler gauge is removed.

e. With the amplifier in normal position (handle on top), the tension on the thin contact spring should be increased, so the relay

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will not operate on 40 volts, but will operate on 50 volts. Be sure to maintain the above clearances.

f. When the relay is properly adjusted, the contacts will remain open for all possible positions of the microphone when it is not energized.

g. If the faulty operation is not corrected by the above procedure, make a complete check of the circuit with Test Set I-56-C.

35. CONTROL BOARD BD-85-(*).

Normal readings on the meters of Control Board BD-85-(*), with the test key on CIRCUIT TEST, are as follows:

Plate voltage—90 volts.

Station battery voltage—24 volts.

Station battery current—0 ampere (current drawn by timing fork is too small to register).

Recording lamp current—3.0 amperes approximate (dependent on rheostate setting).

Outpost current—up to 15 milliamperes (varies with length of line.

Microphone channel plate current—4.0 milliamperes.

Observe the station battery voltage and current during operation of the recording motor and cutter. If the station battery is discharged, or if one or more cells have high internal resistance, the battery voltage under load will drop to considerably less than 24 volts. This will cause improper functioning of Relay Unit BK-9-(*) and other equipment operating from the 24-volt source. A similar reduction of voltage may be caused by poor contact at the battery connections, binding posts, or plug and socket connections. In case of failure, check all battery voltages and connetions, and replace fuses where necessary. If the fault is not located by the above procedure, check the circuits with Test Set I-56-C.

36. RELAY UNIT BK-9-(*).

a. Inspect the relays periodically. Clean all dirty contacts, using Tool Equipment TE-37, and if contacts are badly pitted or burned,

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install new springs. If failure of contacts is due to faults in other parts of the equipment, correct these faults before Relay Unit BK-9-(*) is replaced on the control board.

b. The adjustments of relays 1, 2, 4, and 6 are similar in that the clearance between the armature and the top of the support should be .002 to .003-inch. This is attained by moving the armature which is held by one screw in back of the support.

c. Adjust the residual screw until it extends .002 to .003-inch below the armature. This is measured by placing a gauge between the armature and the pole piece.

d. With a .013-inch gauge between the residual screw and the pole piece, and the armature pressed against the pole piece, bend the armature arm so it just touches the contact spring.

e. With a .006-inch gauge between the residual screw and the pole piece, and the armature pressed against the pole piece, bend the heavy contact springs so that they just touch. This allows approximately .010-inch of travel for the contacts when the gauge is removed.

f. Adjust the tension of the contact springs on the relay so that the relay will operate when a resistance of 2,000 ohms is in series with the outpost.

g. On relay 3, the two adjusting screws should have a gap of approximately .025-inch on each side of the vibrating reed contact. This adjustment will cause the motor to operate for approximately 4 seconds after the film is cut. If the motor runs more than 4 seconds, turn each screw inward an equal amount until the desired 4-second run is attained.

h. Now adjust the inner spring contact so that there is a .010-inch clearance between the contacts when they are in normal position.

i. Adjust relay 5 for a .002 to .003-inch clearance between the armature and the top of the support.

j. Adjust the residual screw to extend .002 to .003-inch below the armature.

k. The tension of the vibrating reed spring should be great enough to hold the stop against the back of the support.

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l. The tension of the inner spring should hold the armature firmly against the stationary stop.

m. Bend the stop spring so that there is a .025-inch gap between the contacts.

n. The gap between the residual screw and the pole piece should be .020 to .030-inch, depending on the tension of the vibrating reed spring, and is attained by bending the armature.

o. If the space on the film between the identification and recording lines exceeds 3 inches, the residual screw should be turned in slightly.

p. On relay 6, the recording and timing lamp contacts should make simultaneously. If they do not, adjust them by bending until they do.

q. For sufficient exposure of identification, adjust the tension of the thin contact springs on relay 4 with the rheostat turned fully clockwise.

CAUTION.—IF THE TENSION OF THE SPRINGS ON THE RELAY IS TOO GREAT, THE IDENTIFICATION LAMPS WILL STAY LIGHTED, AND THE RELAY UNIT WILL CEASE OPERATION.

37. SWITCHBOARD BD-62-(*).

a. Keep the switchboard free from dirt and chemicals to prevent corrosion and short-circuiting of the drops, keys, and relays. Inspect all components periodically, and make necessary repairs with Tool Equipment TE-37.

b. Adjust the bracket in back of the relays so there is a .002 to .004-inch clearance between the armature and the top of the support. This will keep the armature from binding when the coil is energized.

c. Adjust the residual screws in both relays so there is .002 to .003-inch clearance between the armature and the pole piece when the residual screw is held firmly against the pole piece.

d. With the armature in its normal position (the arm insulation resting against the contact spring) there should be a clearance of .013-inch between the residual screw and the pole piece. This is obtained by bending the relay arm.

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Section V
SUPPLEMENTARY DATA

	Paragraph
List of Replaceable Parts	38
List of Components	39
Index of Manufacturers	40

38. LIST OF REPLACEABLE PARTS.

a. Amplifier of Microphone T-21-(*).

Ref. No.	Stock No.	Name of part	Description	Function
1-1	3D177A	Capacitor CA-177-A	0.5-*uf*.	Filter
1-2	3D177A	Capacitor CA-177-A	0.5-*uf*.	"
1-3	3D177A	Capacitor CA-177-A	0.5-*uf*.	"
1-4	3D177A	Capacitor CA-177-A	0.5-*uf*.	"
1-5	3D177A	Capacitor CA-177-A	0.5-*uf*.	"
2	3D155A	Capacitor CA-155-A	0.01-*uf*.	Coupling
3	3D157	Capacitor CA-157	0.02-*uf*.	"
4	3D156A	Capacitor CA-156-A	0.002-*uf*.	Shunt, condenser head
5	3Z6850	Resistor	50-megohm, 1-watt	Load condenser head
6	3Z6829	Resistor	20-megohm, ½ watt	Grid, 1st stage
7-1	3Z6810-5	Resistor	10-megohm, ½ watt	Filter
7-2	3Z6810-5	Resistor	10-megohm, ½ watt	Screen grid

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8	3Z6805-6	Resistor	5-megohm, ½ watt	Grid, 2nd stage
9	3Z4534	Resistor RS-134	1-megohm	Plate, 1st stage
10-1	3Z4562	Resistor RS-162	0.25-megohm	Filter
10-2	3Z4562	Resistor RS-162	0.25-megohm	"
11	3Z5998	Resistor	8.0 - 8.3 ohms, ½ watt	Voltage dropping
12	2Z7649-6	Relay (see note 1)	2 pairs make contacts	Switch

b. Control Board BD-85-(*).

201	3F1005-21	Ammeter	0-5 amp	Recording lamp current
202	3F8050-10	Voltmeter	0-50 volts	Station battery voltage
203	3F1020-11	Ammeter	0-20 amp	Relays and IE-14 current
204	3F3470-Z	Milliammeter	0-15 Milliamp	Outpost current
205	3F8100-2	Voltmeter	0-100 volts	Microphone voltage
206	3F3470-1	Milliammeter	0-10 milliamp	Microphone current
207	4C5208DA	Key (see note 2)	Lever, 2 way	Test key
208	4C5208DA	Key (see note 2)	"	Station battery key
209	4G385A/T1	Transformer	Output	Output coupling
210	3Z2587	Fuse	¼-amp	Circuit protector
211	3Z2015-1	Fuse	15-amp	"
212	3Z1925	Fuse FU-25	5-amp	"
213	3Z1926	Fuse FU-26	1-amp	"
214	2Z8778	Socket SO-78	8 contacts	Oscillograph connections
215	2Z8799-25	Socket SO-125	9 contacts	Power connections

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LIST OF REPLACEABLE PARTS (Continued)

b. Control Board BD-85-(*). (Continued)

Ref. No.	*Stock No.*	*Name of part*	*Description*	*Function*
216	4C4365	Frame jack strip	16 contacts	Relay unit connections
217	3Z5983	Resistor	0.3 ohm, 20-watt	Voltage dropping resistor
218	2Z392	Attenuator	10/10 ohms	Output control
219	4G385A/S1	Socket	2 contacts	Input connection

c. Relay Unit BK-9-(*).

1	2Z7645	Relay (see note 1)	Double winding	Switch, counter and alarm
2	2Z7645	Relay (see note 1)	"	Switch, microphone, cutter, identification lamps
3	2Z7649-7	Relay (see note 1)	Single winding	Switch, motor delay
4	2Z7649-4	Relay (see note 1)	"	Switch, seal, motor, identification lamps
5	2Z7649-8	Relay (see note 1)	"	Switch, time delay
6	2Z7649-4	Relay (see note 1)	"	Switch, cutter, lamps
7	3Z7200-3	Rheostat	200-ohm, 6-watt	Time delay adjustment
8	3Z6030-23	Resistor	300-ohm, 1-watt	Filter
9	3Z6045-9	Resistor	450-ohm	Time delay
10	3D177A	Capacitor CA-177-A	0.5-*uf*, 400-volt, d-c	Filter

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d. Switchboard BD-62-(*)

101	2Z7645	Relay (see note 1)	Single winding	Ringing relay
102	2Z7645	Relay (see note 1)	"	"
103	4F2544	Ringing transformer		Ringing current
104	4C1527AW	Buzzer		Alarm
105	3C1712A	Retardation coil	24-volt, d-c	Filter choke
106	3C44	Induction coil	24-volt, d-c	Audio transformer
107	3C323-2A	Choke coil	4 terminals	Filter choke
108	4C3503	Drop M-203 (modified)		Call indicator
109	3Z6015-9	Resistor	150-ohm, 1-watt	Filter
110	3DA250-6.1	Capacitor	0.25-*u*f., 200 volt, d-c	"
111-1 to 8	3DB1.763	Capacitor	1.0-*u*f., 200-volt, d-c	Coupling condenser
111-9 to 16	3DB1.763	Capacitor	1.0-*u*f., 200-volt, d-c	Filter
112	3D177A	Capacitor CA-177-A	0.5-*u*f., 400-volt, d-c	Coupling Condenser
113	4C4319	Jack	Tip and ring	Circuit patching
114	4C4277	Jack JK-37	Telephone jack	Connection to handset
115	4C4314	Jack	Tip and ring	Circuit patching
116	4C5208DA	Key (see note 2)	Lever, 2-way	Ringing and alarm circuit key
117	4C5208DA	Key (see note 2)	"	Outpost circuit key
118	4C5208DA	Key (see note 2)	"	Microphone circuit key
119	3Z1926	Fuse FU-26	1-amp	Circuit protector

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LIST OF REPLACEABLE PARTS (Continued)

d. Switchboard BD-62-(*). (Continued)

Ref. No.	*Stock No.*	*Name of part*	*Description*	*Function*
120	3Z1925	Fuse FU-25	5-amp	Circuit protector
121	4G4762B/S7	Socket	2 contacts	Output connection

e. Oscillograph Equipment IE-14-(*).

301	4G435	Counter	Single winding	Record Counter
302	4G5132	Time marker unit	Motor, tuning fork, etc.	Timing lines
303	4G820	Oscillograph unit jack	16 jacks	
304-1	6Z6827	Lamp LM-30	27-volt	Time lamp
304-2 to 5	6Z6827	Lamp LM-30	27-volt	Identification lamp
305	4G1240	Lamp LM-40	4.2-volt	Recording lamp
306	3Z7000E5	Rheostat	½-ohm, 25-watt	Recording lamp control
307	3Z5996-1	Resistor	6.0-ohm, 20-watt	Heater current limiter
308	3Z6008-1	Resistor	80-ohm	Lens heater
309	3Z6001F6	Resistor	16-ohm	Developer heater
310	3Z6004A5-3	Resistor	45-ohm, 20-watt	Filter
311	3Z6010-30	Resistor	100-ohm, 20 watt	Cutter holding current limiter
312	3Z6001-11	Resistor	10-ohm, 50-watt	Motor speed control
313-1 to 3	3DB1.763	Capacitor	1.0-*uf*., 200-volt, d-c	Filter
314	3D177A	Capacitor CA-177-A	0.5-*uf*., 400-volt, d-c	Filter

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315	3H3111	Motor		Camera drive motor
316	2Z7686	Relay		Cutter operation
317	4C5208DA	Key (see note 2)	Lever, 2-way	Counter & fork control
318	4C5208DA	Key (see note 2)	"	Lamp & motor control
319	4C5208DA	Key (see note 2)	"	Heater control
320	2Z8778	Socket SO-78	8 contacts	Oscillograph connection
321	2Z8799-25	Socket SO-125	9 contacts	Power connections
Fig. 4	4G1666A	Oscillograph unit M-166-A	Moving-coil type	Sound record
Fig. 4	3E1475	Cord CD-475	Plug-ended each end	Galvanometer connection

f. Headset HS-30 (*).

Stock No.	*Name of part*	*Description*
2B730	Headband HB-30	
2B2030(*)	Receivers R-30-(*)	
3E1620(*)	Cord CD-620-(*)	2-conductor
2B1300	Inserts M-300	

g. Chest Set TD-1.

4B418	Chest Unit T-26	
3E333	Cord CC-333	6-ft., 3-conductor
4B2358	Plug PL-58	
4Z6924	Strap ST-24	
4Z6925	Strap ST-25	
3Z8118	Switch SW-118	

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LIST OF REPLACEABLE PARTS (Continued)

h. Tool Equipment TE-37.

Quantity	*Name and Description*	*Manufacturer's Stock No. (Automatic Electric Co.)*
1	Gauge, thickness	H-46755-1
1	Pliers, duck-bill	H-50620
1	Tool, spring bender	20777
1	Tool, spring bender	42873
1	Tool, spring bender	7066
1	Tool, armature stop bender	14769
1	Tool, armature bender	14768
1	Tool, contact cleaner	H-42962-1
1	Tool roll, canvas, No. 10 hard-texture, olive drab duck, with individual compartments for tools listed, side flaps, and webbing strap with buckle.	

i. Tool Set TE-6.

Stock No.	*Quantity*	*Name*	*Description*
6Q8112-18	24	Blade, hacksaw	12-in., 18 teeth per inch
6Q19077	1	Chest BC-77	Oak
6Q19808-6	1	Chisel, cold	½ by 6 in.
6Q27502	1	Cleaner, file	

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6Q34530	1	Drill, hand	Ratchet
6Q36160	1 set	Drill, twist	Steel, Nos. 1 to 60
6Q38503-4	4	File, round	Second cut, 4-in.
6Q38503-6	6	File, round	Second cut, 6-in.
6Q38603-4	4	File, square	Second cut, 4-in.
6Q38030-8	6	File, flat	Bastard, 8-in.
6Q41000	1	Frame, hacksaw	Adjustable, 8 in. to 12 in.
6Q46315	1	Grinder, tool	Hand, bench, 1 by 5 in. wheel
6Q50004	1	Hammer, riveting	4-oz., cast steel
6Q51185-5	2	Handle, soldering iron	Wood, 5-in.
6Q51131-5	1	Handle, file	Malleable iron
6Z7300-75	1	Oiler	¾-oz., coppered steel, 4-in. bent spout
6R2082M	1	Oilstone, soft	Mounted, 8 by 2 by 1 in.
6Z7492	1	Padlock MC-92	For Chest BC-77
6R4513	1	Pliers TL-13	Side-cutting, 6-in.
6R4603	1	Pliers TL-103	Diagonal-cutting, 5-in.
6R4626	1	Pliers TL-126	Long-nose, 6-in.
6R7508	2	Punch, center	½-in. diam. by 4 in.
6R19100	1	Screwdriver Set TL-128	Includes ratchet screwdrivers, drill points, chuck, countersink, etc.
6R14970	1	Screwdriver TL-25	Jewelers', swivel-head
6R19507	1	Screwplate set	Taps and dies, NC 4-36 to 14-20, in wood case

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LIST OF REPLACEABLE PARTS (Continued)

i. Tool Set TE-6. (Continued)

Stock No.	*Quantity*	*Name*	*Description*
6R24011	1	Shears, tinner's hand	Snips, 11 in. over-all, 2½-in. cut
6R24508	1	Soldering iron	Size 1, ½-lb.
6R24524	1	Soldering iron	Size 3, 1½ lb.
6N7531	1 lb.	Solder M-31	Resin core
6R25506	1	Square, combination	6-in.
6R42100	1	Torch, blow	Gasoline, 1-qt.
6R47020	1	Vise, bench	2-in., solid back jaw, swivel base

NOTE 1.—When ordering, specify contact arrangement, number of coils, reference number, and function.

NOTE 2.—When ordering, specify contact arrangement, reference number, and function.

39. LIST OF COMPONENTS

Quantity	*Stock No.*	*Article*	*Dimensions (inches)*			*Unit Weight (pounds)*
			Height	*Width*	*Depth*	
5 gal.	8A802-2	Alcohol, ethyl, denatured				
10	4G197	Bag BG-97	18	5	2	1
8	3A26	Battery BA-26	4½	8¼	7⅜	14.5
20	3A28	Battery BA-28	11/16	2	2¼	0.12
120	3A30	Battery BA-30		1¼ diam.	2¼	0.25
16	3B29	Battery BB-29; includes 8 spare	8-9/16	9⅞	8	35

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1	3B4295	Battery tester, heavy discharge type	3	5	8	2
1	4C310D	Bell, switchboard, 24 volt, d-c.	6	3	1½	1.5
10 feet	6Z922LR	Belting, leather, round ⅛ in.				
18	4E681	Block, protector, carbon	¾	⅜	⅜	0.03
18	4E682	Block, protector, bakelite	¾	⅜	⅜	0.03
8	4G290	Bucket, enameled steel, 10-qt.	12	10 diam.		2
6	3D157	Capacitor CA-157, (Spares)				
6	3D155A	Capacitor CA-155-A, (Spares)				
6	3D156A	Capacitor CA-156-A, (Spares)				
12	3D177A	Capacitor CA-177-A, (Spares)				
2	3DA250-6.1	Capacitor, .25μf., 200 volt, d-c (Spares)				
6	3DB1.763	Capacitor, 1.0 μf., 200 volt, d-c (Spares)				
1 tube	6G199	Cement, household, waterproof				
10 lb.	8A802-1	Chemical, acid, acetic, glacial, C.P. 99 per cent				
30 lb.	8A802-5	Chemical, ammonium chloride, grade A				
4 lb.	8A802-10	Chemical, metol				
2 lb.	8A802-12	Chemical, hydroquinone				
20 lb.	6G1910-1	Chemical, sodium hydroxide, U.S.P.				

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LIST OF COMPONENTS (Continued)

Quantity	Stock No.	Article	Dimensions (inches) Height	Width	Depth	Unit Weight (pounds)
200 lb.	8A802-27	Chemical, sodium thiosulfate (hypo) photographic, pea-crystals				
50 lb.	8A802-30	Chemical, sodium sulfate, anhydrous, photographic				
1	6F705	Chest BC-5	28⅞	18⅛	12	35
2	4G340B	Chest CH-40-(*)	11	25¼	47½	84½
1	4G344A	Chest CH-44-(*)	15¾	14½	25½	46
1	4G345A	Chest CH-45-(*)	13¼	15½	48½	57
1	4G346A	Chest CH-46-(*)	13⅛	12½	36½	34
1	4G347A	Chest CH-47-(*)	16⅝	12¼	38¼	37
1	4G348A	Chest CH-48-(*)	17⅜	14¾	43¼	53
1	4B417	Chest Set TD-1 (Note 3)				
2	4G355	Clamp MM-7	8	8	¾	6
50 yards	6N1619	Cloth, birdseye				
1	4G385	Control Board BD-85-(*)	12½	8¾	32⅜	36
10	3E66	Cord CC-66, length 18 inches				
2	3E67	Cord CC-67, length 36 inches				
1	3E1250A	Cord CD-250-A, length 50 feet				

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15	3E1428	Cord CD-428, length 5 inches includes 6 spares			
2	3E1438	Cord CD-438, length 20 feet			
1	3E1439	Cord CD-439, length 20 feet			
1	3E1443	Cord CD-443, length 17¼ inches			
2	3E1444	Cord CD-444, length 14 inches			
8	3E1475	Cord CD-475, length 8 inches			
10	3E2038	Cord CO-38, length 12 inches			
4	3E2050A	Cord CO-50-A, length 72 inches			
1 oz.	6B400	Cotton, absorbent			
1	4G394	Cover BG-74	18	4	8.5
24	4G1321B/D1	Diaphragm, aluminum, 7 x 7 x .001 inches thick	18		
2	8A980	Drier, film			
4 oz.	8A802-38	Ether			
1	6Z4002A.1	Flashlight TL-122-A			
4	8A1174	Funnel PH-174			
18	3Z1910	Fuse FU-10, 3-amp, tubular			
24	3Z1925	Fuse FU-25, 5-amp.			
24	3Z1926	Fuse FU-26, 1-amp.			
24	3Z2015-1	Fuse, 15-amp.			

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LIST OF COMPONENTS (Continued)

Quantity	Stock No.	Article	Dimensions (inches) Height	Width	Depth	Unit Weight (pounds)
18	3Z2427	Fuse, 5-amp., tubular				
24	3Z2587	Fuse, ¼-amp.				
20	4G1321B/G1	Gasket, 1/16-inch, neoprene, large				
20	4G1321B/G2	Gasket, 1/16-inch, neoprene, small				
2	4G632	Graduate, enameled steel, white 32-ounce	7	4 diam.		0.75
10	5B4416	Ground Rod GP-16	24	½ diam.		1.5
1	3Z3329	Ground Rod GP-29	36	2¼ diam.		8
1	4B1109-(*)	Handset TS-9-(*)	9	3	3	1.1
		Handset TS-9A (4B1109A) through TS-9-Q (4B1109Q) may be issued.				3
1	2B830-(*)	Headset HS-30-(*). If Headset HS-30-(*) and Chest Set TD-1 are not available, Head and Chest Set HS-19-A (4B-1279A) may be issued.				
2	3B2202	Hydrometer HY-2	12¾	2	2-7/16	0.25
3	3B2600	Jug, gallon, glass, clear				
3	3B2600.1	Jug, gallon, glass, brown				
10	6Z6827	Lamp LM-30, 27 volt				

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10		6Z6761A	Lamp LM-35-A				
10		4G1240	Lamp LM-40, 3.7-amp., 4.2-volt				
2	cans	6G1315	Lubricant, household				
10		4G1406A	Microphone Shelter BE-66-A		21 diam.	1	4
10		4G1321B	Microphone T-21-(*), includes 2 spares	16	6 diam.		24
8		4G166A/C1	Moving coil system for Oscillograph Unit M-166-A. Not issued with GR-3-C. To be stored at depot for repair of Oscillograph Unit M-166-A.				
2	cans	6G1350	Oil, Gargoyle Velocite, grade E				
1		4G1614C	Oscillograph Equipment IE-14-(*) Includes 8 spare Oscillograph Units M-166-A.	19	11	36½	90
2		4G1741	Outpost Connecting Box BE-71	4½	2	1½	1
2		4G1751	Outpost Unit BE-51	2½	3¼	7	6
2		6M1220.3	Pad, stamping, black				
140	rolls	8A2852	Paper, recording, roll 250-feet long, 35-mm wide	3	6 diam.		2.5
12		6M1030	Pencil, red, china marking				
2		6R3000	Pick, railroad type, with handle				

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LIST OF COMPONENTS (Continued)

Quantity	Stock No.	Article	Dimensions (inches) Height	Width	Depth	Unit Weight (pounds)
2	4B2358	Plug PL-58	2¼	2	2	0.12
10	4E4004	Protector AR-4	7⅝	3½	3	1
1	4E4008	Protector AR-8	16	12 diam.		13
1	2Z7649-6	Relay, (Spare)	3½	1¼	2¼	0.75
2	4G1909	Relay Unit BK-9-(*), includes 1 spare	4½	8	4½	6
6	3Z4534	Resistor RS-134, 1-megohm, ½-watt (Spares)				
6	3Z4562	Resistor RS-162, 0.25-megohm, ½-watt (Spares)				
6	3Z5998	Resistor, 8.0-ohms, ½-watt (spares)				
6	3Z6805-6	Resistor, 5-megohms, ½-watt (spares)				
6	3Z6810-5	Resistor, 10-megohms, ½-watt (spares)				
6	3Z6820	Resistor, 20-megohms, ½-watt (spares)				
6	3Z6850	Resistor, 50-megohms, 1-watt (spares)				
3	8A3430	Rod PH-230, stirring				
1	8A3614A	Scale PH-14-A	5	8	5	1
1	8A3624	Scale PH-114, 4-16	5	12	5	4
2	6R22019	Shovel LC-19	37-overall			5

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1	6R24639	Soldering Iron TL-139				
1	6Z8369	Sponge, cellulose, fine pore				
1	4G1909/S1	Spring assembly for relay AQA-1 (spare)				
1	4G1909/S2	Spring assembly for relay AQA-2 (spare)				
1	4G1909/S3	Spring assembly for relay AVR-3 (spare)				
1	4G1909/S4	Spring assembly for relay ASO-4 (spare)				
1	4G1909/S5	Spring assembly for relay AWS-5 (spare)				
1	4G1909/S6	Spring assembly for relay ASO-6 (spare)				
1	4G1614C/S1	Spring assembly for cutter relay (spare)				
2	6M1201	Stamp, identification, rubber				
½ lb.	6Z8420	Stopper, cork, No. 5				
6	6Z8421	Stopper, rubber, No. 5, one-hole				
½-lb.	6Z8422	Stopper, rubber No. 6				
1	4G4762 (*)	Switchboard BD-62-(*)	8½	8¾	32⅜	27.4
3	4B5008 (*)	Telephone EE-8-(*)	3½	7-7/16	9½	4
1	3F4065 (*)	Test Set EE-65-(*). Test Sets EE-65-A (3F4065A) through EE-65-D (3F-4065D) may be issued.	8	10	6	14
1	3F4056C	Test Set I-56-C	11	13½	9½	26
2	8A3828	Thermometer PH-28				

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LIST OF COMPONENTS (Continued)

Quantity	*Stock No.*	*Article*	*Dimensions (inches)* Height	Width	Depth	*Unit Weight (pounds)*
1	6R38037	Tool Equipment TE-37	4	2 diam.		0.75
1	6R38006	Tool Set TE-6	6 cu. ft.			108
28	2T27	Tube VT-27 (includes 18 spares)				
24	2T44	Tube VT-44 (includes 14 spares)				
3	4G5600	Tubing, pyrex, right-angle (includes 2 spares)				
24 feet	7A1930	Tubing, rubber, grade B, 3/16-inch bore				
2	6R4600	Tweezers, brass				
3 lb.	6Z8813	Twine RP-13				
1,000 feet	1B520	Wire, No. 20, rubber-covered, hook-up				
50 feet	1B816.4	Wire, No. 16, rubber-covered, 2-conductor, lamp cord				

40. INDEX TO MANUFACTURERS.

Name	Address
American Automatic Electric Sales Co.	1033 W. Van Buren St., Chicago, Ill.
Engineering Laboratories, Inc.	624 E. Fourth Street, Tulsa, Okla.
Wallace & Tiernan Products, Inc.	Belleville, N. J.

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(A.G. 062.11 (4-26-43).)

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,

Chief of Staff.

OFFICIAL

J. A. ULIO,

Major General,

The Adjutant General.

DISTRIBUTION:

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(For explanation of symbols see FM 21-6.)

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